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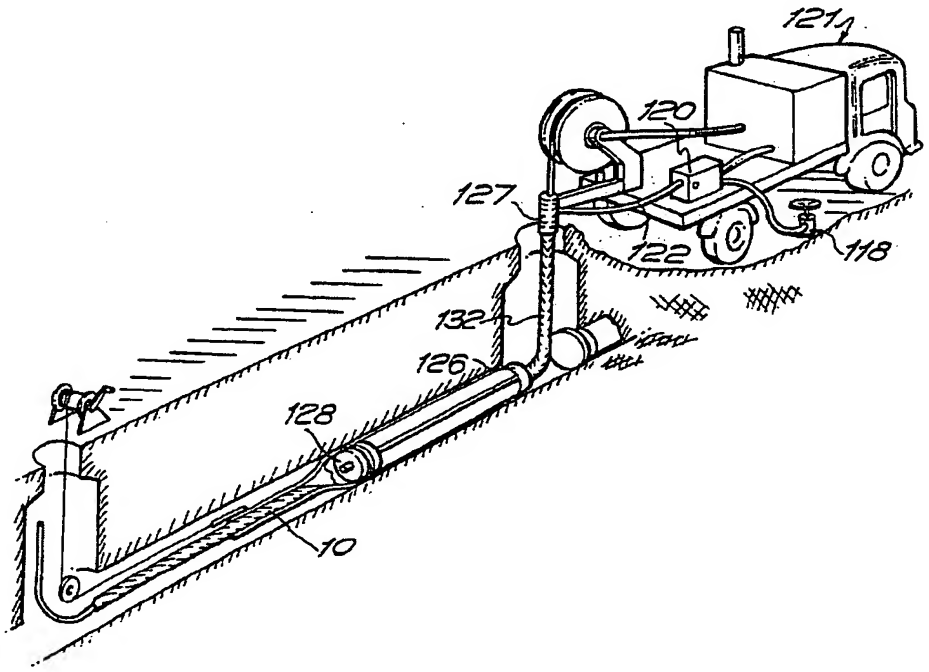

(57) Abstract

The invention provides that a rigid plastics material (preferably p.v.c.) pipe (10) is provided with folds and is introduced into a pipeline or passageway and heat is applied to the pipe to soften same. The hot pipe is unfolded and using fluid pressure, is expanded onto the pipeline or passageway surface to line same. When the pipe cools or is cooled, it remains in position on said surface. The pipe is folded into petal or star shape in cross section, and it may be twisted for even bending and/or it may be everted into the pipeline or passageway. Several methods of insertion are disclosed.

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IMPROVEMENTS RELATING TO THE LINING OF PIPELINES OR PASSAGEWAYS

This invention relates to the lining of pipelines or passageways, in particular underground pipelines or passageways typically used for the transportation of sewage.

Sewage systems comprise main sewage pipes and laterals sewage pipes, the lateral sewage pipes connecting buildings such as offices and dwelling houses to main sewage pipes. The present invention has application to main and lateral sewage pipes and initally it is expected that it is in connection with such pipes that the invention would be used, but it is to be mentioned that the method can be used in connection with industrial pipes and water distribution pipes and indeed in connection with the lining of any pipeline or passageway having the appropriate requirement. The lining of pipelines or passageways may be effected for preventing the egress or ingress of liquid out of or into the pipeline or passageway, or it may be for the purposes of changing the use of the pipeline or passageway or rendering it suitable for carrying a material such as a chemical for which it may otherwise be unsuitable. The lining may be effected furthermore in order to prevent or limit corrosion. The invention is concerned with the lining of pipelines or passageways using plastic pipes which are rigid when at ambient temperature, but which are capable of undergoing deformation in order either to effect a reduction in the overall diameter of the pipe and/or to effect an increase in overall diameter of the pipe so that the plastic pipe can be inserted into the pipeline or passageway in reduced diameter condition, and when in the pipeline or passageway can be expanded up to the diameter of a pipeline or passageway to be lined. This method of lining is of course already known, and examples of the method have been disclosed in the following published patent specifications:- British patent application 2188695, European patent

specification 0065886, U.K. patent specification 2003576, British patent 1580438, British patent 1553408 and British patent 1437273.

The general concept of lining pipelines or passageways using plastics material pipes which are rigid at ambient temperature is distinguised from the widely practiced so called "soft-lining" methods of pipelining, wherein a flexible or "soft" liner is impregnated with a synthetic resin, and the soft liner in such condition is shaped by fluid pressure to the wall of the pipeline or passageway to be lined, and then the resin is cured or caused to cure so that the lining becomes a rigid pipe on the wall of the pipeline or passageway to be lined. The most commonly practiced technique of soft lining is disclosed in U.S. patent 4064211.

The present invention is concerned with the lining method using plastics pipe which is rigid at ambient temperature.

As described in the prior art, various plastics material may be used for the rigid pipe and mainly such plastics material comprises polyethylene, especially high density polyethylene or p.v.c. It is usual furthermore for the rigid pipe to be associated with heating to enable deformation of the pipe to a reduced diameter or to an increased diameter or both, and high density polyethylene has the advantage that it will soften generally speaking at a much lower temperature than will p.v.c., for example in the order of 95 degrees as compared to 125 degrees, which makes high density polyethylene attractive in some cases because it will be easier at least on site to soften the polyethylene. However, p.v.c. has the advantage that it is on a thickness for thickness basis generally speaking stronger material than polyethylene and therefore when it is installed it will have better strength characteristics than the polyethylene pipe.

This makes the use of p.v.c. attractive.

Another distinguishing characteristic as between polyethylene and p.v.c. is that if a polyethylene pipe is deformed from circular cross-section by the use of heat and deformation forces, and then is cooled in a deformed state so as to retain the deformed shape, when it is subjected to reheating, as soon as it starts to soften, it tends to return to the original circular shape, whereas if similar operations are carried out on a p.v.c. pipe, as the p.v.c. pipe starts to soften, it will not tend to return to the circular shape and in fact will simply become more floppy and pliable. Use can be made of these characteristics in connection with the utilisation of plastic pipes for lining pipelines or passageways. Thus, in the case of the polyethylene pipe which has been deformed from circular shape and has been inserted in a pipeline or passageway, the application of heat will assist the pipe in returning to the circular shape which means that less pressure will be used to shape the polyethylene pipe to the pipeline or passageway surface. However, polyethylene does have the disadvantage that the temperature to which the pipe can be heated is somewhat critical and if the heating temperature exceeds a certain value, for example in the order of 115 degrees C, then the integrity of the polyethelene pipe can be destroyed and it will simply melt and become unusable. With p.v.c. pipe however it can be heated over a much wider range and still retain its integrity so that it can be inflated whilst hot without any resulting loss in strength when the inflated pipe is eventually cooled and rigidifies in position on the pipeline or passageway surface.

The above relates to the technical reasons as to why in some cases polyethylene may be used whereas in other cases p.v.c. may be preferred, but in fact as regards the present invention any suitable thermal plastic pipe which has the characteristic that the material is rigid

at ambient temperature, can be used. The present invention is concerned with a number of aspects which facilitate and improve the basic rigid plastic pipe lining process.

In the prior specifications referred to above, it is known to deform a circular cross-section plastic pipe into U section, H section or petal section in order to reduce the overall diameter of the pipe to enable it to be inserted into a suitable pipeline or passageway and in particular reference is made to European patent specification 0065886 in this regard, but in fact deforming the rigid pipe in this fashion results in a deformed pipe which does not have similar bending characteristics in all directions. For example if the pipe is deformed into U shape, then bending about a plane parallel to but lying between the limbs of the U will be much simpler than bending in a plane at right angles thereto. Because of this, the feeding in of the pipe into a pipeline or passageway can be difficult if the passageway is not completely straight, and in any event it is usually necessary for the rigid pipe to be capable of some bending as it is fed from ground level into the end of the underground pipeline or passageway. It is known from the aforesaid British patent specification no. 2188695A to preheat the rigid deformed pipe to enable it readily to be bent around various curvatures to enable it to be fed into the pipeline or passageway.

In the first aspect of the present invention, a rigid plastic pipe of thermoplastic material has folds therein and is capable of being heated and expanded to a larger diameter during which expansion the folds unfold, and wherein the pipe is twisted so that axially of the pipe the fold lines follow a helical path.

By this arrangement, the pipe exhibits a better

characteristic of bending in any direction, because the cross-section of the pipe in effect twists along the direction of the pipe so that the overall resistance to bending in any direction is constant.

The plastic pipe is preferably folded so as to define petal shapes in cross-section, and the folding is such that the folded pipe in cross-section has at least 3 axes of symmetry. By providing that the cross-section has at least 3 axes of symmetry, then it can be arranged that the bending effort required about any of these axes to give the same amount of bending is approximately equal, and even by the folding design, it can be achieved that the pipe will have a substantially even bending characteristic even if the aforesaid twist were not present. The present invention therefore covers a rigid thermoplastics pipe with folding therein, and the pipe having at least 3 axis of symmetry, which preferably are offset by 120 degrees.

The pipe may be formed to the folded condition either by being directly extruded in such condition, or it may be heated whilst in circular condition, and then provided with radial folds to provide the desired cross-section. The twisting, when provided may be imparted during extrusion of the pipe, or during subsequent folding but it is unlikely that the twisting will be imparted before the pipe is provided with the said folds.

When the folded pipe is placed in the pipeline or passageway, it is important to ensure that it unfolds in a controlled fashion, and in accordance with a second aspect of the invention, a method provides that the folded pipe is placed in the pipeline or passageway, and it should be mentioned in this aspect that it is not necessary that the pipe should be folded and/or twisted in accordance with the first aspect of this invention, and then the pipe is progressively unfolded to circular

form to be applied to the pipeline or passageway surface by means of an expanding device which urges the opening pipe against a shield located to the outside of the pipe, and which travels with the expanding device along the pipeline or passageway as the plastic pipe is opened up, and the method also including that the plastic pipe, at least in the region which is opening up, is heated to a sufficient degree to enable the pipe to unfold.

The shield may be defined by a sleeve which fits neatly to the pipeline or passageway surface and neatly receives the folded plastic pipe in its bore or it may be a collar which surrounds the folded rigid pipe. It could also be a steam jacket which surrounds the rigid folded pipe with clearance to enable steam to be introduced between the jacket and rigid pipe, the steam jacket leading to a bell mouthed shield of which the bell mouth lies adjacent the enfolding or opening portion of the rigid pipe, said bell mouth serving to retain a chamber of steam around the opening rigid pipe for the application of heat thereto, but so that steam can escape from the clearance between the opening rigid pipe and the bell mouth casing.

In some cases it may not be necessary to provide the reaction shield referred to above, and in such circumatances the expansion device may comprise a rolling pig or a bucket pig which is forced through the rigid pipe so as to lie slightly upstream of the region of the rigid pipe which is for the time being, being heated.

Where the shield is provided, it is preferably pulled along the pipeline or passageway ahead of the opening rigid pipe.

In yet a further aspect of the invention, the opening up of the rigid pipe can be effected by means of

progressive heating using hot water which issues from a hot water feed tube which is inserted into the end of the rigid pipe, and from which hot water issues in order to contact the inner surface of the rigid pipe. The feed pipe is progressively fed along the inside of the opening rigid pipe thereby progressively to heat and inflate the rigid pipe. The downstream end of the rigid pipe may be sealed by means of a stopper which has a bleed valve therein in order to allow a small leakage of the hot water through the inside of the rigid folded pipe for the pre-heating of same prior to unfolding.

As to the method of inserting the rigid pipe into the pipeline or passageway prior to the opening up of same, this may be effected by means of a pulling or pushing action, and it may be passed over a heating box in order to soften the pipe to enable it to be correctly positioned and fed into the pipeline or passageway.

It will be appreciated that as regards the first aspect of the invention, which relates to the structure of the rigid pipe, then any convenient method of insertion and inflation may be adopted.

Another known method of lining passageways is referred to by the name slip lining. In slip lining a semi-rigid plastics material tube approximating to the diameter of the passageway to be lined is simply pulled into the passageway and any clearance between the passageway surface and the outer surface of the lining tube may be filled with grouting material to complete the operation. It will be understood that slip lining is limited in its use insofar as the passageway which can be lined by the slip lining method has to be substantially straight. The soft lining methods can be used for passageways which have substantial curves and bends therein. The soft lining methods furthermore provide that the final lining will lie close to the passageway surface and no

additional grouting step is required. The flexible lining methods also are capable of being carried out in single shots over long lengths of passageways. This means that a single long length tube can be inserted in a passageway to line same without there being any joints in the finished lining pipe. Slip lining has the advantage that the lining tube is fabricated under factory conditions, and its character does not change between insertion and job completion whereas in the soft lining processes, it is not always possible to be sure that either the bonding material has bonded the soft lining tube to the passageway surface or the resin in the tube has cured evenly throughout its length.

The present invention in another aspect seeks to provide a method of lining passageways which has the advantages of both of the known systems without the disadvantages.

In accordance with another aspect of the present invention, a method of lining a passageway comprises the utilisation of a rigid or semi-rigid tube of thermoplastics material which in an initial condition is of smaller overall dimensions than the diameter of the passageway to be lined, and wherein the tube is fed in the initial condition into the passageway, and inside the passageway the tube is everted to a final condition where it lies against the passageway surface lining same.

In the initial condition, the tube may have folds therein in order to reduce its overall diameter or alternatively in the initial condition it may be circular and of smaller diameter than the passageway to be lined. In this connection, the plastics material of the tube may be of a type having a memory so that the tube is first of all produced in the final diameter size and then is heated to soften same and the tube is stretched to the initial diameter and then cooled to

rigidify the tube in the initial diameter size. In this condition the tube retains a "memory" so that when the tube is again heated it will freely expand to the final diameter size.

To enable the tube to evert from the initial condition to the final condition, heat is applied to soften the thermoplastic material of the tube but only sufficient heat to enable the tube to be re-shaped and so as to avoid melting of same.

The heat may be applied in any suitable manner. For example the eversion of the tube inside the passageway may be effected by fluid under pressure, and that fluid may be heated. At the same time heated fluid may be applied to the inside of the tube to give even heating and even softening of same.

In a particularly preferred method, a heating means such as a radiant heater or a stream heated block is provided in the passageway ahead of the everting face so as locally to heat the everting face to allow the eversion to continue. With this arrangement, it may be possible to cause the eversion simply by applying thrust to the inwardly travelling pipe on the initial diameter section of same without requiring the use of fluid pressure.

Where a steam heated block is provided, the block may contact and be moved along the passageway by the everting face so that heat is applied to the everting face by conduction.

It is obviously most desirable if the softening of the pipe to permit eversion can take place locally and at the everting face only as then there is no requirement to provide heat sources such as boilers for heating everting fluid. The everting fluid when used typically will be water or steam.

The process according to the invention, at least in its preferred form has the advantages of slip lining and the advantages of soft lining without the abovementioned disadvantages of these processes. That is to say long lengths can be performed in a single shot, the pipe can be made to be a snug fit on the passageway surface without any requirement for grouting, and the even quality of the lining material can be maintained by the utilisation of a rigid plastics material pipe.

Suitable materials which can be used for the process are the thermoplastics materials PVC and polyethylene, but the invention is to be considered as being thereto.

Various embodiments of the present invention will now be described, by way of example, with reference to the accompanying diagramatic drawings, wherein;-

Fig 1 is a sectional view of a pipe of thermal plastic material surrounded by a heater for the heating of same;

Fig 2 shows the heated pipe of Fig 1 when subjected to deformation rolling and folding;

Fig 3 is a view similar to Fig 2 but showing a further stage in the process;

Fig 4 is a sectional view of a rigid thermal plastic pipe folded into a petal configuration;

Fig 5 is a perspective view of the pipe shown in Fig 4, but also illustrating the longitudinal twist therein;

Fig 6 shows the end of an extrusion dye suitable for producing the rigid pipe of section shown in Fig 4;

Fig 7 shows a rigid folded and twisted thermoplastic

pipe according to another embodiment of the invention;

Fig 8 is a sectional elevation showing how the fold in the pipe of Fig 7 are formed;

Fig 9 is a side sectional elevation illustrating the method of forming the pipe shown in Fig 7 from a circular plastic pipe to the folded and twisted form shown in Fig 7, the figure also showing the folded and twisted pipe being wound onto a collecting drum;

Fig 10 is a perspective elevation of the apparatus shown in Fig 9;

Fig 11 is a sectional elevation illustrating the installation of a rigid and folded plastics material pipe into a pipeline or passageway;

Fig 12 is a view similar to Fig 11 but showing an advanced stage of the lining operation;

Fig 13 is a perspective elevation of the rigid lining pipe being expanded in the pipeline or passageway against a steam shield;

Fig 14 is a perspective cutaway sectional view illustrating another method of rigid pipe installation ;

Fig 15 is a view similar to Fig 14 but showing the operation at an advanced stage;

Fig 16 is a sectional elevation showing part of the installation operation in Fig 15;

Fig 17 is a view similar to Fig 14 but showing an alternative method of installation;

Fig 18 is a view similar to Fig 17, but showing an

advanced stage of the installation process;

Fig 19 is a sectional side view of the arrangement shown in Fig 18;

Fig 20 is a sectional view of the arragngement shown in Fig 19 and in particular a detail thereof to an enlarged scale and showing a modification;

Fig 21 is a view similar to Fig 18 but showing an alternative method of installation;

Fig 22 is a view similar to Fig 21 but showing an advanced stage of the installation;

Fig 23 is a view similar to Fig 21 but relates to a modified method of installation;

Fig 24 shows the arrangement of Fig 23 but in an advanced stage of installation.

Figs 25, 26 and 27 show a modification in the method for repairing imperfections in the lining operation;

Fig 28 shows the equivalent used in the modified method of Figs 28, 26 and 27;

Figs 29 and 30 show two further modifications of the method;

Fig. 31 is a sectional elevation through an underground passageway showing a lining method according to another embodiment in operation;

Fig. 32 is a sectional elevation taken on the line II - II in Fig. 31 and; Fig. 33 is a sectional elevation similar to Fig. 1 but showing a modified shape.

Referring to the drawings, it is to be mentioned that all notes and wording and additional diagrams on the drawings are to be considered as part of the specification and the applicant may wish to refer thereto for sustaining any particular disclosure.

Referring now to the drawing in more detail, in Fig 1 a thermal plastics material pipe (10), specifically u.p.v.c. pipe is surrounded by means of a heater (12) which may be an electric resistance heater. The pipe is of indefinite length, and the length will in fact be related to the length of the pipeline or passageway to be lined using pipe (10). Pipe (10) is passed through the heater in the direction of its length so that it will be heated throughout its length and progressively, and the hot pipe is then passed through a forming dyes as shown in Figs 2 and 3 to form the pipe (10) into H configuration. As shown in Fig 2, a pair of deforming rollers (14) and (16) compress the pipe radially, whilst the pair of tucking knives or formers (18) and (20) form inwardly directed folds giving the deformed pipe the H confirguration.

As the pipe progresses in its movement it moves to position between the nip defined by flatening rollers (22) and (24) which form the pipe to the folded flattened condition as shown in Fig 3.

As the flattened and folded tube (10) emerges from the rollers (22) and (24), it is passed directly to a large reeling drum which is best illustrated in Fig 9 and in Fig 10 and reference will be made thereto subsequently. The flattened and folded tube (10) may be cooled prior to reeling if desired, but it is not believed that such cooling will be necessary.

Figs 2 and 3 illustrate only one form to which the tube may be folded, and in fact the folding of a tube to the

H configuration shown in Fig 3 is known in the prior art. It is also known from the prior art to fold the tube into U section and horse shoe section and indeed into petal section, but a first aspect of the present invention provides that the tube (10) is folded into a specific configuration. One example of this specific configuration is shown in Fig 4.

The tube (10) is made up of circular arcs so as to define 3 deep folds (26) and 3 shallow folds (28). The folded tube in fact has 3 axes of symmetry (30) (32) and (34) which are angularly offset by 120 degrees. The various circular dimensions D12 D2 and D3 are of the proportion shown, the distance D being the overall diameter of the folded tube. A tube formed into this configuration has excellent bending characteristics insofar as it will have the same resistance or susceptibility to bending in virtually any direction, so that the tube can be readily bent in being fed round corners in the pipeline or passageway or in being fed into the pipeline or passageway as will be described. The folded tube (10) may be extruded in this form, or it may as described in relation to Figs 2 and 3 be heated and deflected to this shape.

Fig 5 shows that the tube (10) shown in Fig 4 in addition to having the petal cross section shown also is twisted longitudinally which even further enhances the capability of the pipe to bend evenly in any direction. Because of this capability, when the pipe is being inserted into a pipeline or passageway it is not necessary to control the attitude of a pipe having regard to the direction in which it must bend.

Figs 7 to 10 illustrate another folded and twisted pipe configuration. As best shown in Fig 7, the pipe is folded so as to define 6 petals (36) which have radial sides and curved outer surfaces of which the curvature

is equal to the initial curvature of the circular undeflected pipe. The fold lines (38) which arise as a result of the longitudinal folds twist helically along the length of the pipe.

Fig 8 shows how the pipe of Fig 7 is formed from an originally circular pipe (40). The pipe (40) is heated over segmental and evenly spaced portions (42) of which the alternate regions (42) are longer than the remaining regions and a plurality of radial formers (44) and (46) deflect the heated portions inwardly as shown in Fig 8, the formers (44) deflecting the heated portions inwardly to a greater extent than the formers (46). The formers (44) and (46) may in fact as shown in Fig 10 be circular discs which rotate as the tube (40) is fed into the eye formed by the edges of the discs, as better described in relation to Fig 10. The unheated portion (48) of the pipe (40) remain of the same radius but are moved progressively inwardly with the folding of the heated portions until the resulting deformed tube (10) as shown in Fig 8 results. As the pipe (40) is so heated and deformed it is also twisted into the configuration shown in Fig 7 and eventually is wound onto a take-up drum.

Figs 9 and 10 show the apparatus for deforming and twisting the heated pipe (40). As shown in Fig 9, the pipe (40) enters a heating pedestal (50) having a heating tube (52) in which the respective circumferential portions (42) and (48) are heated and maintained cold respectively. Hot and cold chambers (52) and (54) are created by radial dividing partitions (56) and hot air is supplied to the chambers (54) through pipe (58) and is returned through a cold air pipe (60). As the pipe (40) passes through the pedestal (50) therefore it is heated as illustrated in Fig 8. A drive motor (62) and a drive belt (64) drive a die plate through which the heated pipe is passed in order to impart a twist thereto, and the forming discs (44) and

(46) engage the moving pipe (40) to form the eventual twisted pipe (10) which is wound onto the take-up reel (66) for storage. The resulting pipe (10) may be cooled if desired, but in any case it will cool when on the reel (66) and the hot portions of the pipe will eventually rigidify. The reeled pipe is stored until it is to be used for lining a pipeline or passageway.

Reference will now be made to Figs 11 and 12 which show a first embodiment of inserting a folded rigid thermoplastic pipe into a pipeline or passageway followed by the expansion of same onto the pipeline or passageway surface. In the example of Figs 10 and 11, an underground sewer (68) is connected by a pair of manholes (70) and (72). The distance between the manholes (70) and (72) will be greater than that shown, but only a short distance is illustrated in the interests of clarity. The reel (66) carrying the pipe (10) to form the lining is encased in a suitable casing (74) which may be a tarpaulin or the like, and trunking (76) leading from the reel to the bottom of man-hole (72) conects with the casing (74). The trunking (76) is open at the bottom, and steam is issued from a steam generation apparatus (75) through a supply pipe (78) to cause the steam to flow into the trunking (76) which has the effect of pre-heating the pipe (10) as it is unwound as shown from the reel (66) and is pulled into and along the sewer (68) by means of a winch (80) and a cable (82) connected to the free end of the pipe (10) by means of a coupling (84).

When the pipe (10) has been placed in position as shown in Fig 12, it is cut to length, and then a rolling pig device (86) described in greater detail hereinafter is introduced into the right hand end of the pipe (10) after it has been heated, and a pressure coupling (88) enables the supply of air under pressure from a compressor (90) via a pipe (92) to a location behind

the pig (86) in order to force same along the inside of the pipe (10) to expand same onto the sewer surface. The pipe (10) is heated from a steam generation apparatus (94) through a feed pipe (96) and a steam heating collar of the type shown in Fig 13.

Referring to Fig 13, the end of the pipe (10) is shown as projecting through a coupling (98), and connected to the coupling is a heat resistant flexible hose (100) to the opposite end of which is connected a bell shaped housing or shield (102). The steam hose (96) is connected to the coupling (98) so as to supply steam to the interior of the hose (100) and to the exterior of the pipe (10) and also to the interior of the shield (102) so that the pipe (10) inside the hose (100) and the shield (102) is heated to softened condition so that it will expand upon the forcing of the pig (86) along the interior of the expanded pipe (10). The steam hose is also used to pull the assembly comprising coupling (98) hose (100) and shield (102) in the direction of arrow (104) as the expansion of the tube (10) continues. It is to be noted from Fig 13 that as regards a lateral sewer pipe (106) which meets the main sewer (68) the expanded tube (10) will be dimpled into the lateral pipe (106) as indicated by reference (108) and such dimple will be clearly visibly when the interior of the lined sewer is subsequently inspected by a T.V. camera or the like. When the dimple is identified, it is then a simple matter of cutting the dimple out by a suitable cutter to re-establish a connection between the lateral sewer (106) and the main sewer (68).

Therefore as the expansion progresses, so the pipe (10) is heated only over a section preceding the pig (86). The pig furthermore reacts against the shield (102), and so is prevented from progressing at too quickly a rate and the whole assembly moves along the pipe (10) expanding same as it proceeds. In the arrangement of

Fig 13, the rigid folded pipe (10) is shown as having the H configuration illustrated in Fig 3, but obviously it is not necessary that this should be the case.

In the insertion arrangement illustrated in Figs 14, 15 and 16, the method is basically the same as already described in so far as steam is introduced through the man hole (70) via a steam insertion pipe (96). The pipe (10) is pre-inserted into the sewer (68). A pig (86) is used for the opening up of the pipe (10), but in this case a device sometimes referred to as a poly-pig (110) is used as a sleeve around the portion of the pipe (10) immediately ahead of the pig (86). The sleeve (110) acts as a reaction member for the rolling pig to prevent same from progressing too quickly, but the sleeve (110) as shown in Fig 16 does not provide for the steam heating. The steam heating is effected by means of a pair of nozzles (112) connected to the poly-pig (110), but arrange to supply steam into the folds (28) and (26) as shown in Fig 4 for the heating of the section of the pipe (10) ahead of the rolling pig (86). Fig 16 again shows the dimpling effect (108) and the pig is shown in slightly more detail. It will be seen to comprise a valve (112) through which air or water under pressure can be introduced or established in the correct pressure inside the pipe.

The steam supply pipes (96) are also used for dragging the nozzles (112) and the poly-pig (110) along the sewer ahead of the rolling pig. The poly-pig provides an excellent of means of preventing cold water from coming into contact with the section of the pipe (10) which is being heated. It is important that water be kept clear of this heating zone, as water has the effect of chilling the pipe and preventing the effect of softening of same. Where the pipe is dry, it is not necessary to use a poly-pig and in fact a flared sleeve can be used, the flared sleeve simply providing the feature of

housing the rigid pipe (10) and providing a reaction surface against which the rolling pig can react.

The poly-pig has an inner sleeve (116) of p.v.c. or polyurethane but certainly of low friction material such as p.t.f.e. felt. The poly-pig in fact tends to reduce in thickness as it is put under tension as a result of cooling on the steam pipes (96). It may be filled with a liquid or solid film and preferably has an outer casing of polyurethane.

The pig (86) may be driven through the opening pipe (10) by water or air pressure, and Fig 14 shows that water is used and is drawn from the mains (118) and supplied through a flow and pressure control device (120) via a supply pipe (122) which couples with a casing (124) from which the pig can be driven.

In the lining method of Fig 17, again the pipe (10) is placed in the sewer (68), but the pipe end in man-hole (72) is provided with an end formation (126) for receipt of a plug which subsequently will effect expansion of the pipe (10). The plug acts like a piston and in fact has rubber or the like seals, best illustrated in Fig (20) which contact the inside of the expanded pipe (10) as will be explained. The special piston is indicated by reference (128), and connected to the piston is a steam supply hose (130). In order to expand the pipe (10) water from the mains (118) is coupled to a control valve (120) on an installation vehicle (121), and the water output hose (122) is coupled to a gland (127) to which is connected a coupling hose (132). A hose connects with the coupling (126), so that water under controlled pressure can be supplied to the rear side of the piston (128) so that it can be forced through the expanding pipe (10). At the same time, as shown best in Fig 19, the steam pipe (134) which receives steam from a

steam generator (136) mounted on the vehicle (121), and the steam pipe passes through the gland (127) and through the interior of the hose (132) and eventually through the piston (128) so as to issue into the space between the expanding pipe (10) and the piston (128) The hot steam softens the pipe (10) and allows it to expand as shown, and the condensation is allowed to pass through the unexpanded portion of the pipe (10) out of an overspill pipe (138) so as to discharge at a level of a controlled head indicated by reference (140) in Fig 19 in the man-hole (70). An insulation sleeve (142) surrounds the pipe (10) where it expands and slightly downsteam of same, and the sleeve is pulled along passageway (68) by a winch (80) and winch cable (82) as described in relation to Fig 11.

In the illustration of Fig 20, the method illustrated is essentially similar to that shown in Fig 19, except that a poly-pig (110) is used in place of the sleeve (142), and in addition the piston (128) comprises a pair of flexible discs (144) (146) between which is further poly-pig (148) in order to form a good seal between the inner wall of the expander pipe (10) and the piston.

In the arrangement shown in Figs 21 and 22, no specific expanding means is used, and the rigid pipe (10) which is inserted in the sewer (68) as shown in Fig 21 is provided with a water coupling (150) which as shown in Fig 22 is coupled to a heat resistant drop tube (152) lying in the man-hole (72), and which is supported from ground level by means of a gland assembly (154). The gland assembly is coupled to a supply truck (156) so that hot water from tank (158) in the tank can be pumped through a central supply pipe (160) inside the drop tube (152), the supply pipe being located so that its outlet end lies in the vicinity of where the pipe (10) is expanding. In this connection the tube (160) is reeled

on a drive reel (162) which is rotated as the expansion of the tube (10) progresses. In the operation of this method the length of pipe (10) is placed in the passageway (68) and then after coupling the coupling (150) to the tube (160), hot water is pumped out of the end of the tube (160) when it is located at the coupling (150) end of the tube (10) so that end is heated by the incoming hot water. As the heated end expands due to the water pressure, so the water injection tube (160) is progressively fed along the inside of the expanding pipe as shown in Fig 22. When the expansion has been completed, the hot water can be pumped back up the tube (160) and into the tank (158) by coupling an air pump (162) and hose (164) to the gland (154), the hot water can be taken to another installation location. Raising the temperature of the returned hot water to its former level will require less than would be required if the hot water were simply discarded.

The arrangement of Figs 23 and 24 is essentially similar to that shown in Figs 21 and 22 with the exception that the pipe (10) is provided with a control collar or sleeve (166) in the region where the pipe is expanding in order to perform an insulation function. The poly-pigs and reaction sleeves and shield referred to herein can all be arranged to perform an insulating function.

In each of the embodiment of Figs 21 and 22 and Figs 23 and 24, the downstream end of the rigid pipe (10) is provided with a stopper (168) which is designed to have a small leakage characteristic insofaras some of the water supplied to the interior of the pipe (10) to heat and expand same can also leak out of the downstream end. This ensures a good flow of hot water through the entire pipe (10) and a certain amount of pre-heating of the pipe (10) before the expansion of same.

Referring to Figs 25 to 28, these figures show a

modified method compared to the methods already described herein. The method of Figs 25 to 28 is essentially similar, subject to the following modification. As shown in Fig 28, at ground level is provided a television truck (200) which is provided with a steam supply and a steam hose (202) extends from the truck to the vicinity of the lining operation. Additionally, the T.V. cable (204) extends from the truck to a T.V. camera (206) in the pipeline or passageway following behind the rolling pig (208).

A second vehicle (210) connects via the other man-hole to the shield (220) which is similar to the shields described herein via a steam hose (222) and a winching cable (224). The cable (224) also connects with a winching drum in vehicle (200). Figs 25 to 27 show the detail of the components in the pipeline or passageway. The winch cable (224) is shown, and it will be seen to pass through the rolling pig (208). The camera (206) is also shown as is the steam hose (204). The steam hose (204) has an end (204A) adjacent the T.V. camera. Figs 25 to 27 illustrate the effect when the T.V. camera which can view the operation views an imperfection in the lining application as indicated by reference (230). Should this occur, and should it be required that the lining procedure be temporarily reversed, the winch rope (224) is pulled in the opposite direction causing the pig to move backwards as indicated in Fig 26 which has the effect of exposing the portion of the lining to be re-applied. The pig (208) travels over the end (204A) of the steam hose, so that steam can be injected into the region of the imperfectly applied portion (230) of the liner to soften same, and this is followed by causing the pig once more to travel in the forwards direction as indicated by arrow (232) in Fig 27 in order to properly apply the lining. If necessary the lining operation can then proceed at a slower rate.

As regards the modification shown in Figs 29 and 30, in the arrangement of Fig 29, again the pig (208) is illustrated, as is the towing rope (224). This rope is arranged to travel at twice the speed of the winching rope (234) which serves to pull the shield (236), the shield (236) having the same function as the shields hereinbefore described. Again a T.V. camera (206) is provided to complete the ascent and the T.V. camera is used to observe the lining process.

In the arrangement of Fig 29, two pigs (208) and (208A) are used and these are linked by the winching rope (224). A steam hose (204) similar to the hose described in relation to Fig 25 is used for injecting steam into the space between the pigs (208) and (208A) in order to repair a section (230) of imperfectly applied lining.

The present invention provides a useful and effective method for the lining of pipelines or passageways, and also provides improvements in the basic materials used for the lining operation. The heating of the rigid pipe can take place at any appropriate time, and for the formation of the pipe into folded condition, the folding may take place during extrusion or may be performed after extrusion. The pipe may be heated in order to deform same to the folded condition but it will require heat in order to move it to the round contition in which it lines the pipeline or passageway.

When the rigid pipe is inserted into the pipeline or passageway as shown in Fig 11, it is heated before it is introduced into the pipeline or passageway and this may apply in each embodiment. In the alternative it may not be necessary to pre-heat the pipe in order to place it in the pipeline or passageway.

As regards the embodiment of the invention using a rolling pig, if water is used to propel the pig through

the expanding pipe, it is provided the capability of having excellent speed control for the expansion process.

Referring now to Figs 31 - 33 of the drawings, an underground passageway is defined by a pipe 10. The pipe has a bell mouth joint 12, and it is joined by a lateral pipe 14. The passageway may be a sewer, and the lateral pipe 14, may define a connection for example to a domestic dwelling.

The figure shows that the passageway is initially lined by a preliner tube 16, of plastic coated fabric or the like which serves to keep the interior of the pipeline or passageway dry and prevents ingress of moisture from the surrounding ground 18.

The figure also shows that the passageway is lined by means of a plastic pipe 20 of a thermoplastic material which is fed into the pipeline or passageway and everted as indicated at an everting face 22. In this connection the pipe 20 is fed into the passageway in an initial condition as indicated by reference 24, and in which condition the pipe is of lesser overall dimension than the diameter of the passageway to be lined so that the eversion 22 can take place. In the initial condition as shown in Fig 32 the pipe 20 is in star configuration having been formed into this configuration by any suitable means, for example as disclosed herein before. To change the pipe 20 from the initial condition to evert same as indicated at 22 and to apply same to the passageway surface requires the otherwise rigid pipe to be heated so that it will soften and deform to the correct configuration which as shown in Fig 32 is circular. To this end the pipe may be everted by fluid pressure and the fluid supplying the pressure may be hot water or air and will fill the space 26 between the pipe in the initial condition 24 and in its lining position.

That water or air (or steam) may be heated to contribute to the softening of the pipe.

The everting face 22 of the pipe preferably is heated to assist eversion and in this connection heating may be effected by means of a hot block 28 which is a block of steel or the like having passages 30 therein through which steam is supplied. It is noted that the block has a contoured face which will in fact by complimentary to the star shape shown in Fig 32 so that the everting face is heated as evenly as possible. Some of the passageways 30 open to the portion of the block which engages in the centre of the pipe in its initial condition 24 so that steam is fed into the interior 34 of the pipe which also contributes to the heating and softening of same.

The block may be moved along the passageway as indicated by arrow 38 by a tractor device 40 controlled from ground level. The tractor device may also embody a T.V. camera so that the eversion operation can be observed to ensure that the lining is being correctly placed in position.

Because the space 26 is pressurised, the lining 20 will bulge inwardly where the lining meets the lateral pipe 14 so that a dimple 42 will be formed enabling subsequent identification of the locations of the laterals so that the dimple can be cut out to re-establish the lateral connection with the main passageway.

The block 28 will be maintained at the appropriate temperature to facilitate the eversion without melting the plastics material of the pipe 20. The force for everting the pipe may be effected simply by pushing on the pipe in its initial condition 24 as indicated by arrow 44 or such a force may be used in combination with

the fluid pressure.

Where the pipe 20 in the initial condition has to be fed down a manhole and then turned at a sharp angle into the passageway, it may be desirable to soften the pipe so that it can be effectively fed round the sharp corner. Softening will be effected by suitable heating of same.

It is believed that it may be possible to achieve the eversion simply by applying heat only to the everting face 22 and this may be done either by the block illustrated or in a preferred case by a radiant heater which is spaced from the everting face in order to eliminate possible friction.

To commence the eversion operation it may be necessary to apply heat to the leading end of the pipe and to turn it back upon itself so that eversion can be commended but once commenced, eversion should proceed smoothly and evenly resulting in the application of an even thickness and predetermined strength lining tube on the surface of the passageway.

Fig 33 shows an alternative shape for the pipe cross-section wherein the petals 21 are wider on the crests than the grooves 23 making the pipe almost round in cross section. This enables the pipe more reliably to be wound on a storage reel and prevents interlocking of the coils of the pipe when on such reel.

CLAIMS

1. A rigid plastic pipe comprising folds therein which is capable of being heated and expanded to a larger diameter during which expansion the folds unfold, and wherein the pipe is twisted so that axially of the pipe the fold lines follow a helical path.

2. A pipe according to Claim 1 or 2, wherein the pipe is folded so as to define petal shapes in cross-section, and the folding is such that the folded pipe in cross-section has at least 3 axes of symmetry.

3. A rigid pipe according to Claim 1 or 2, wherein the pipe is folded either by being directly extruded in such condition, or it may be heated whilst in circular condition, and then provided with radial folds to provide the desired cross-section.

4. A method of lining a pipeline or passageway wherein a folded, rigid plastics material pipe is used to line the pipeline or passageway and wherein the pipe is placed in the pipeline or passageway and then the pipe is progressively unfolded to circular form to be applied to the pipeline or passageway surface by means of an expanding device which urges the opening pipe against a shield located to the outside of the pipe, and which travels with the expanding device along the pipeline or passageway as the plastic pipe is opened up, and the method also including that the plastic pipe, at least in the region which is opening up, is heated to a sufficient degree to enable the pipe to unfold.

5. A method according to Claim 4, wherein the shield is defined by a sleeve which fits neatly to the pipeline or passageway surface and neatly receives the folded plastic pipe in its bore or the shield may be a steam jacket which surrounds the rigid

pipe with clearance to en
introduced between the jacket and rigid pipe, the steam jacket leading to a bell mouthed shield of which the bell mouth lies adjacent the enfolding or opening portion of the rigid pipe, said bell mouth serving to retain a chamber of steam around the opening rigid pipe for the application of heat thereto, but so that steam can excape from the clearance between the opening rigid pipe and the bell mouth casing.

6. A method according to Claim 4, wherein the expansion device comprises a rolling pig or a bucket pig which is forced through the rigid pipe so as to lie slightly upstream of the region of the rigid pipe which is for the time being, being heated.

7. A method of lining a pipeline or passageway wherein a folded rigid plastics material pipe is used to line tht pipeline or passageway and wherein the pipe is placed in the pipeline or passageway wherein the opening up of the rigid pipe can be effected by means of progressive heating using hot water which issues from a hot water feed tube which is inserted into the end of the rigid pipe, and from which hot water issues in order to contact the inner surface of the rigid pipe.

8. A method according to Claim 7, wherein the feed pipe is progressively fed along the inside of the opening rigid pipe thereby progressively to heat and inflate the rigid pipe and the downstream end of the rigid pipe may be sealed by means of a stopper which has a bleed valve therein in order to allow a small leakage of the hot water through the inside of the rigid folded pipe for the pre-heating of same prior to unfolding.

9. A method according to any of the Claims 4 to 8,

wherein the pipe is inserted into the pipeline or passageway by means of a pulling or pushing action, and it may be passed over a heating box in order to soften the pipe to enable it to be correctly positioned and fed into the pipeline or passageway.

10. A method of lining a passageway comprising the utilisation of a rigid or semi-rigid tube of thermoplastics material which in an initial condition is of smaller overall dimensions than the diameter of the passageway to be lined, and wherein the tube is fed in the initial condition into the passageway, and inside the passageway the tube is everted to a final condition where it lies against the passageway surface lining same.

11. A method according to Claim 10, wherein the tube has folds therein in order to reduce its overall diameter or alternatively in the initial condition it may be circular and of smaller diameter than the passageway to be lined.

12. A method according to Claims 10 or 11, wherein the tube is of a type having a memory so that the tube is first of all produced in the final diameter size and then is heated to soften same and the tube is stretched to the initial diameter and then cooled to rigidify the tube in the initial diameter size.

13. A method according to Claims 10, 11 or 12, wherein to enable the tube to evert from the initial condition to the final condition, heat is applied to soften the thermoplastic material of the tube but only sufficient heat to enable the tube to be re-shaped and so as to avoid melting of same.

14. A method according to Claim 13, wherein the eversion of the tube inside the passageway may be

effected by fluid under pressure, and that fluid may be heated.

15. A method according to Claims 13 or 14, wherein heated fluid is applied to the inside of the tube to give even heating and even softening of same.

16. A method according to Claim 13 wherein a heating means such as a radiant heater or a steam heated block is provided in the passageway ahead of the everting face so as locally to heat the everting face to allow the eversion to continue.

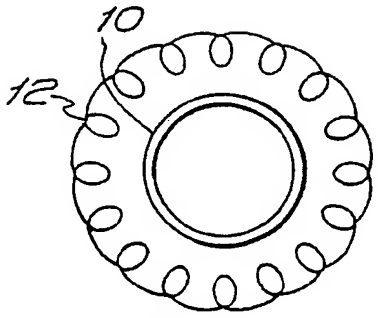


FIG.1

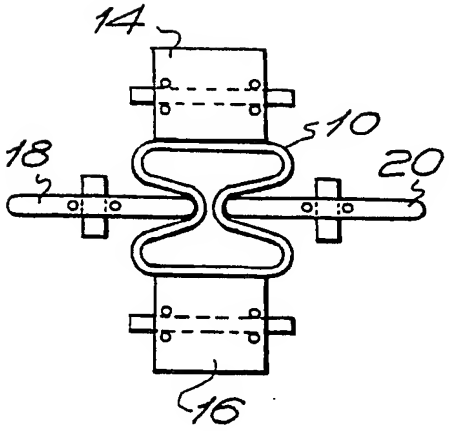


FIG.2

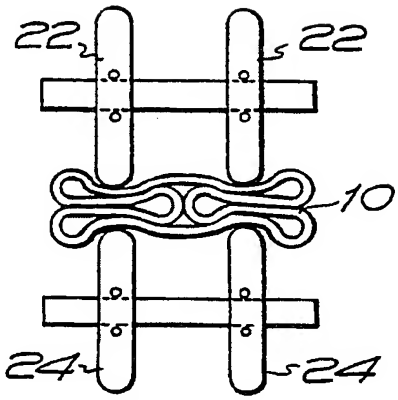


FIG.3

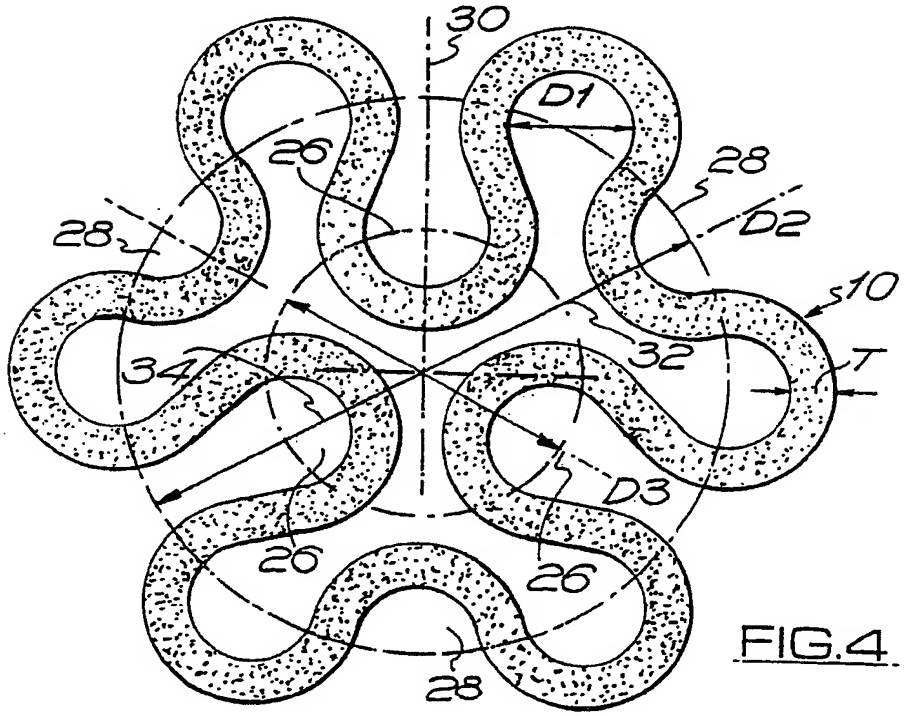


FIG.4

FIG.5

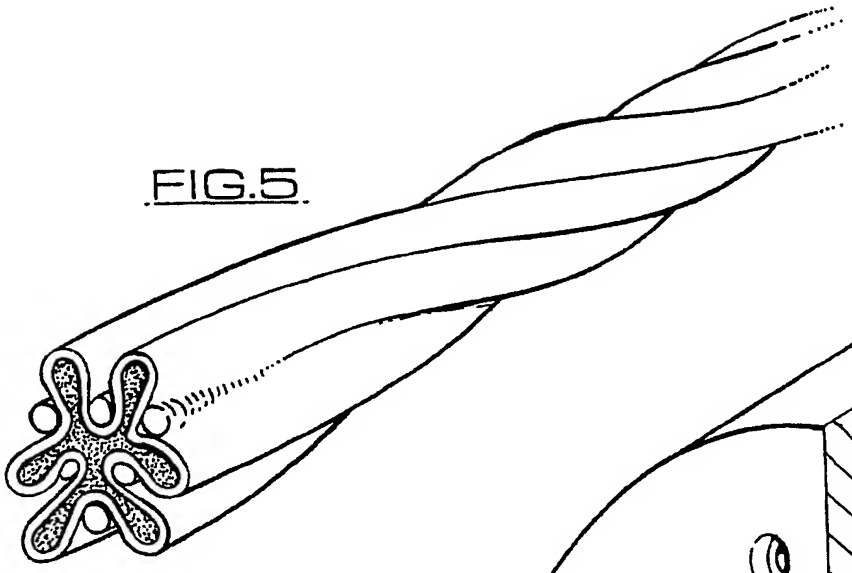
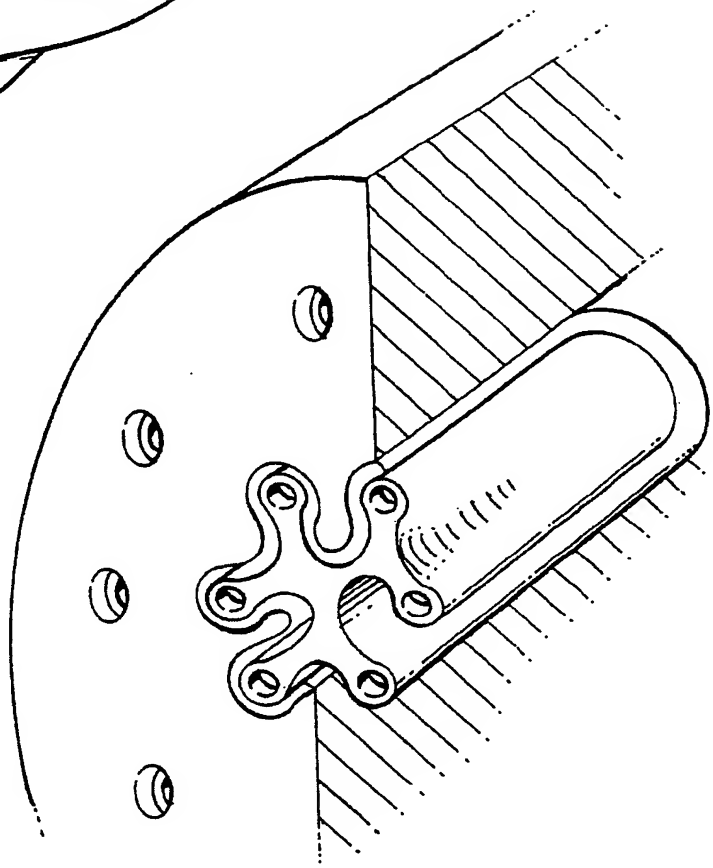


FIG.6



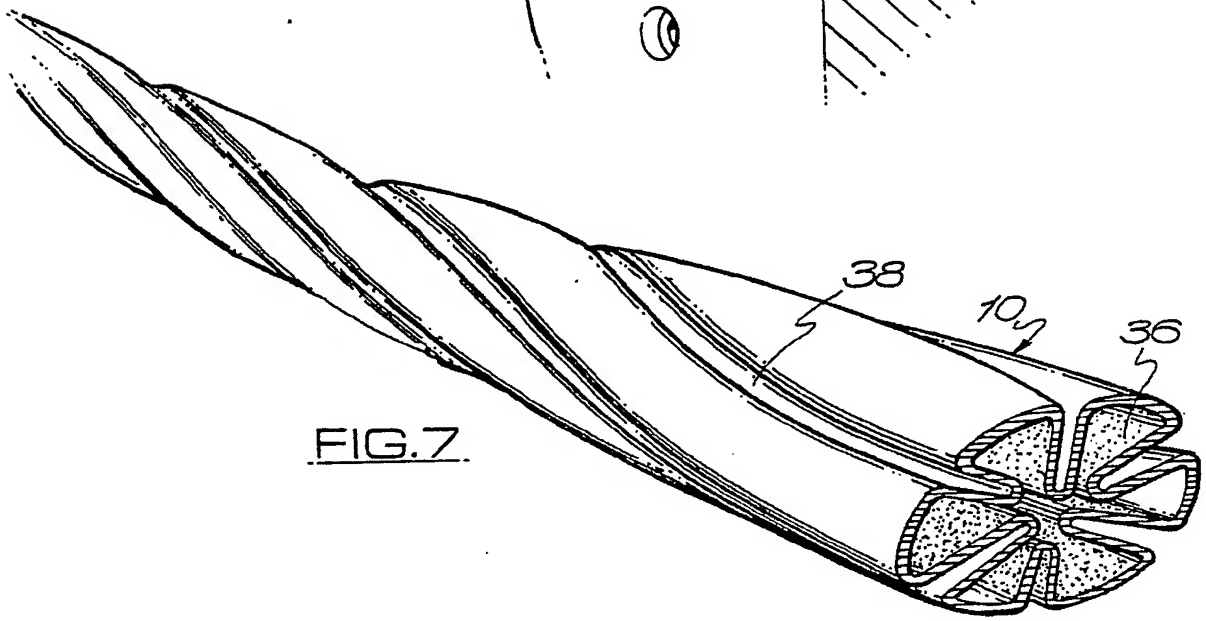


FIG.7

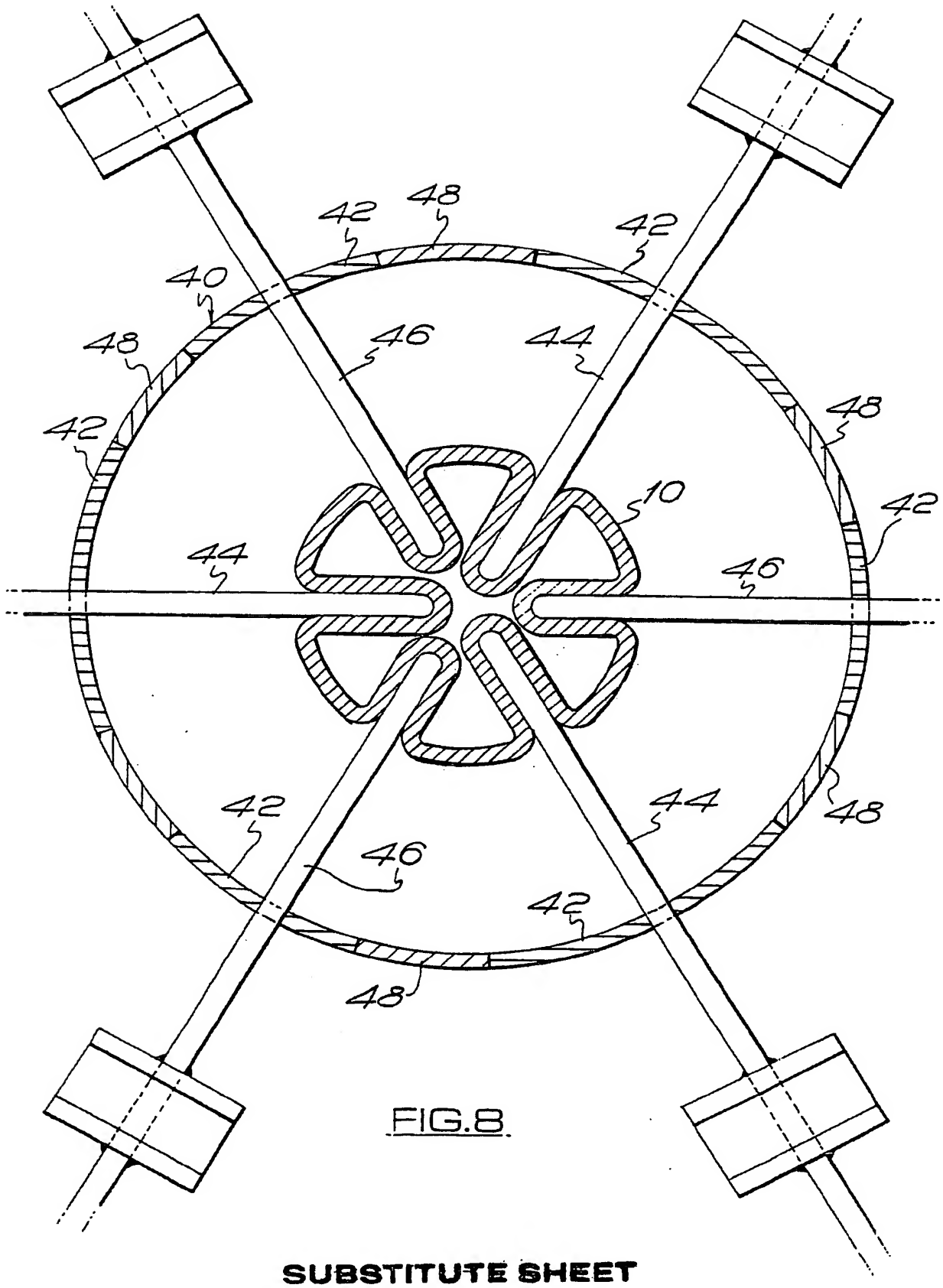


FIG.8

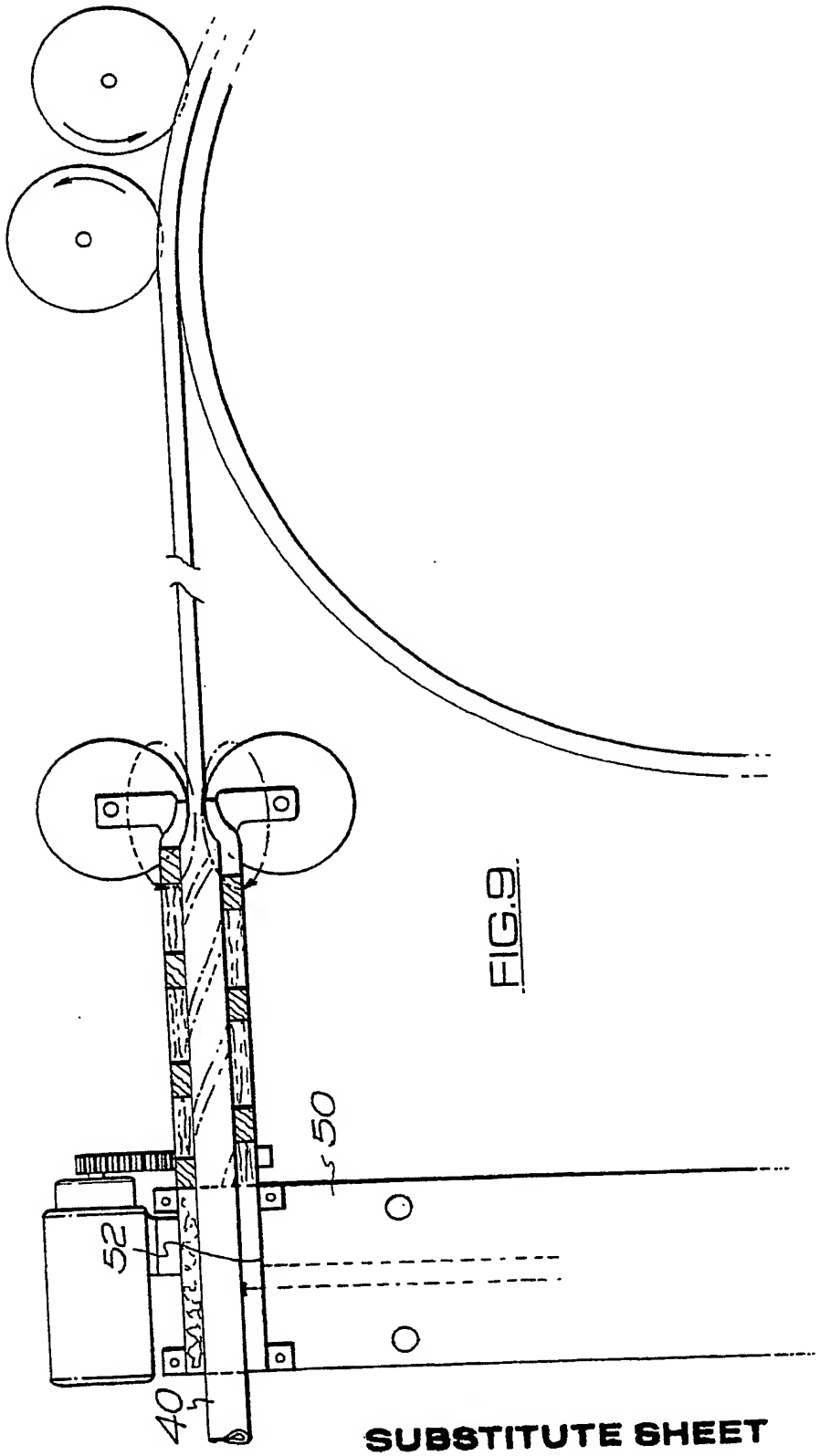


FIG.9.

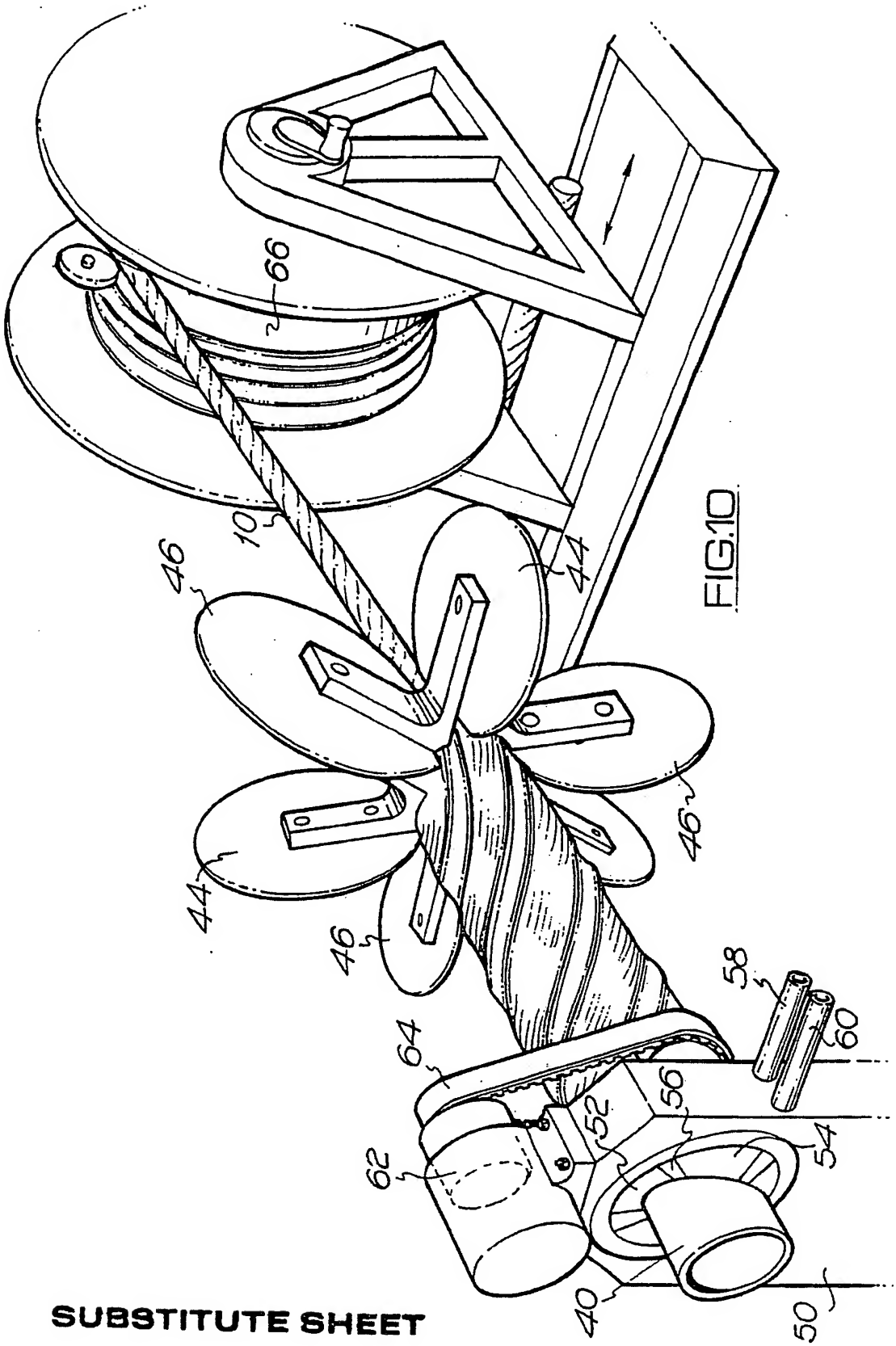


FIG.10

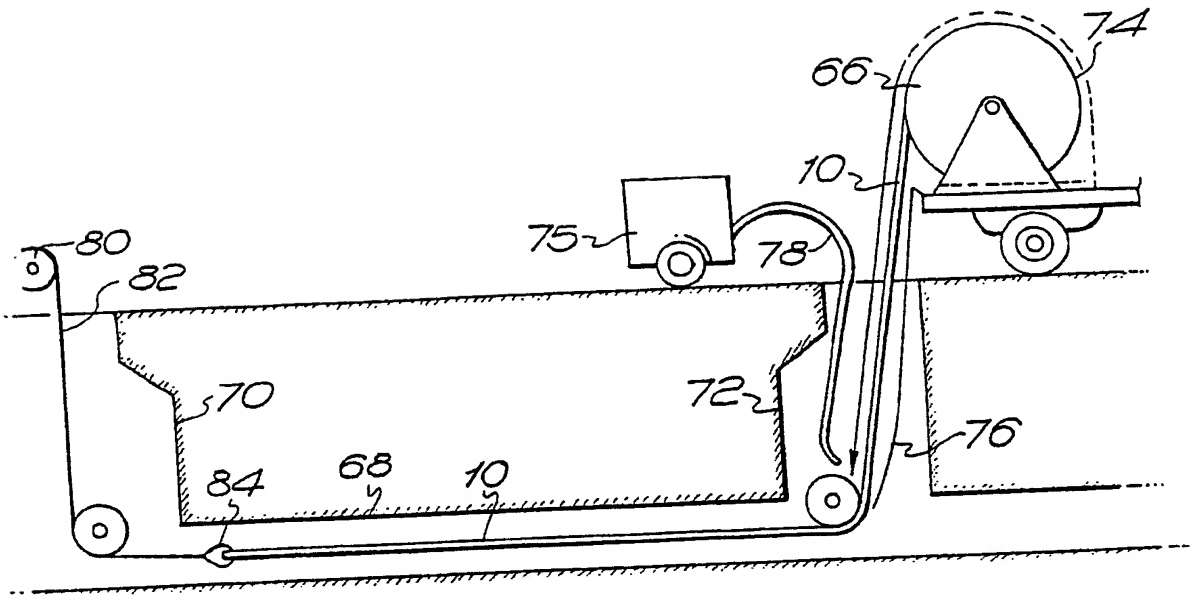


FIG.11

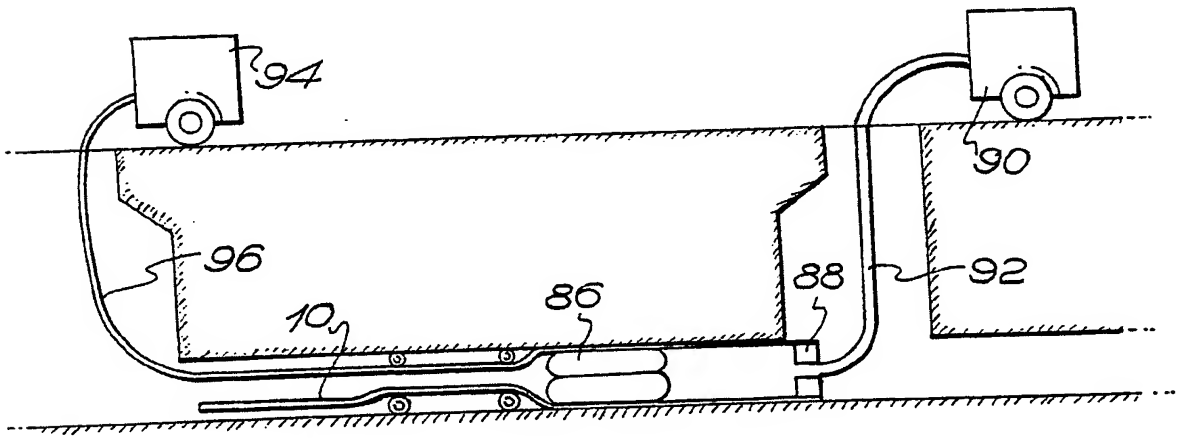


FIG.12

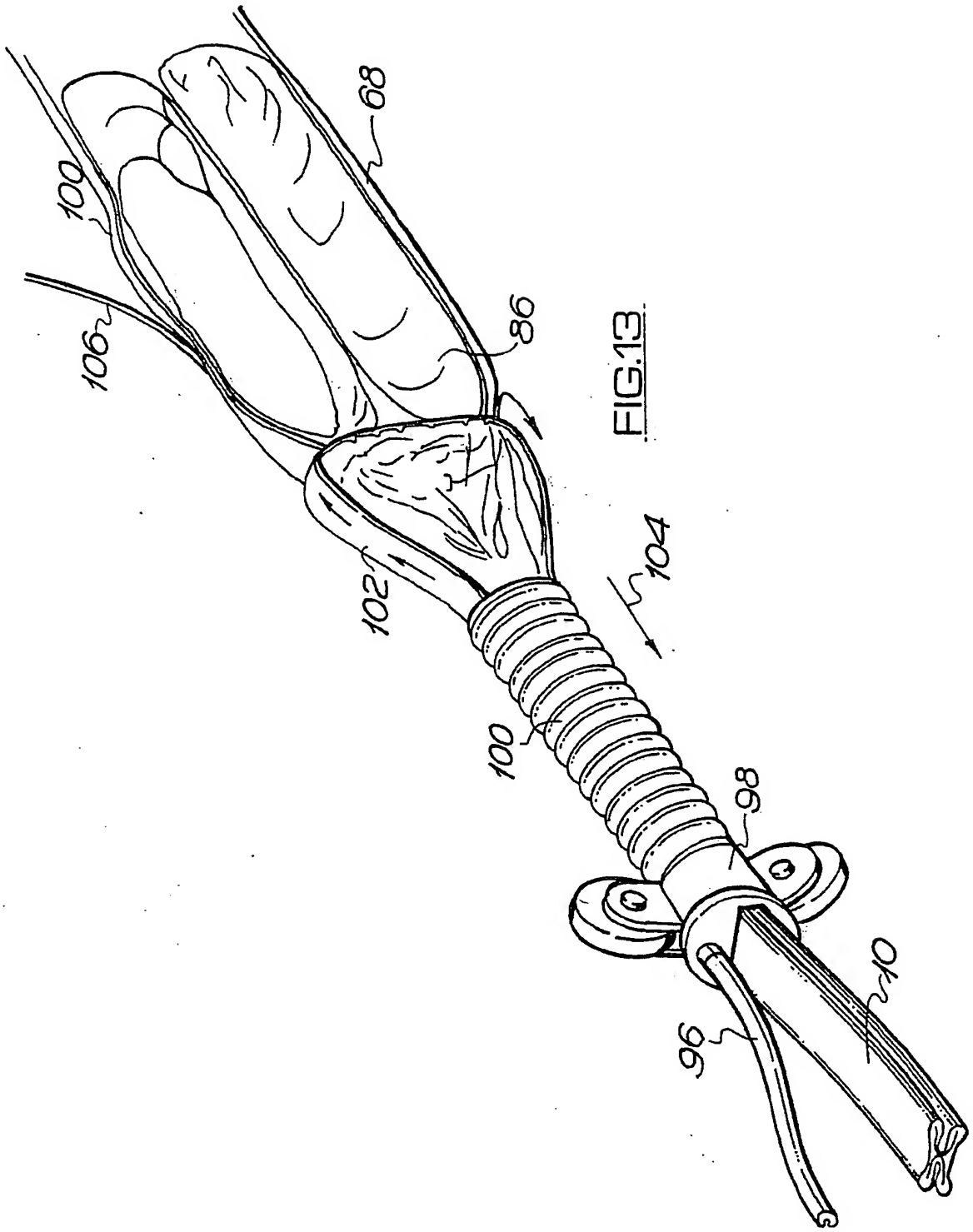


FIG.13

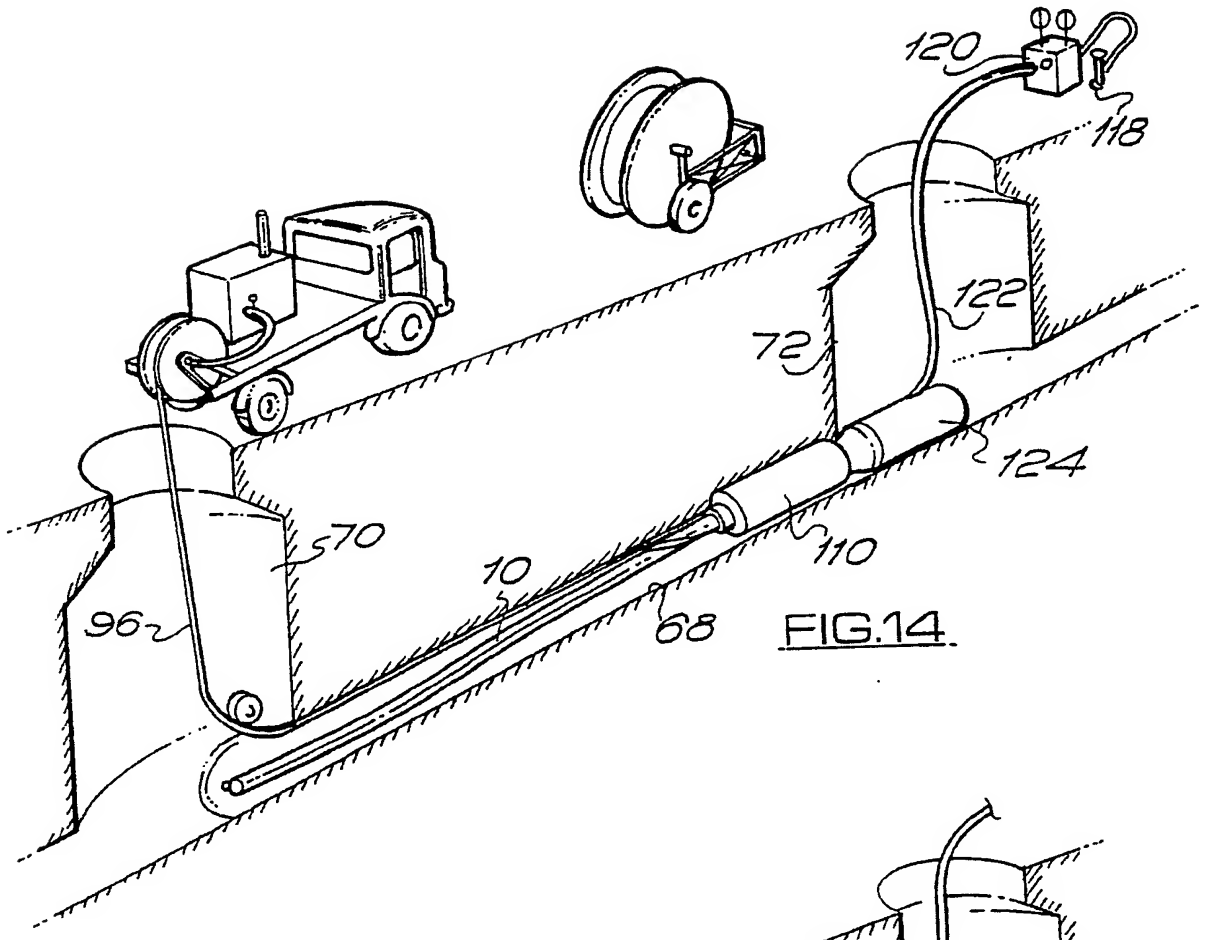


FIG.14.

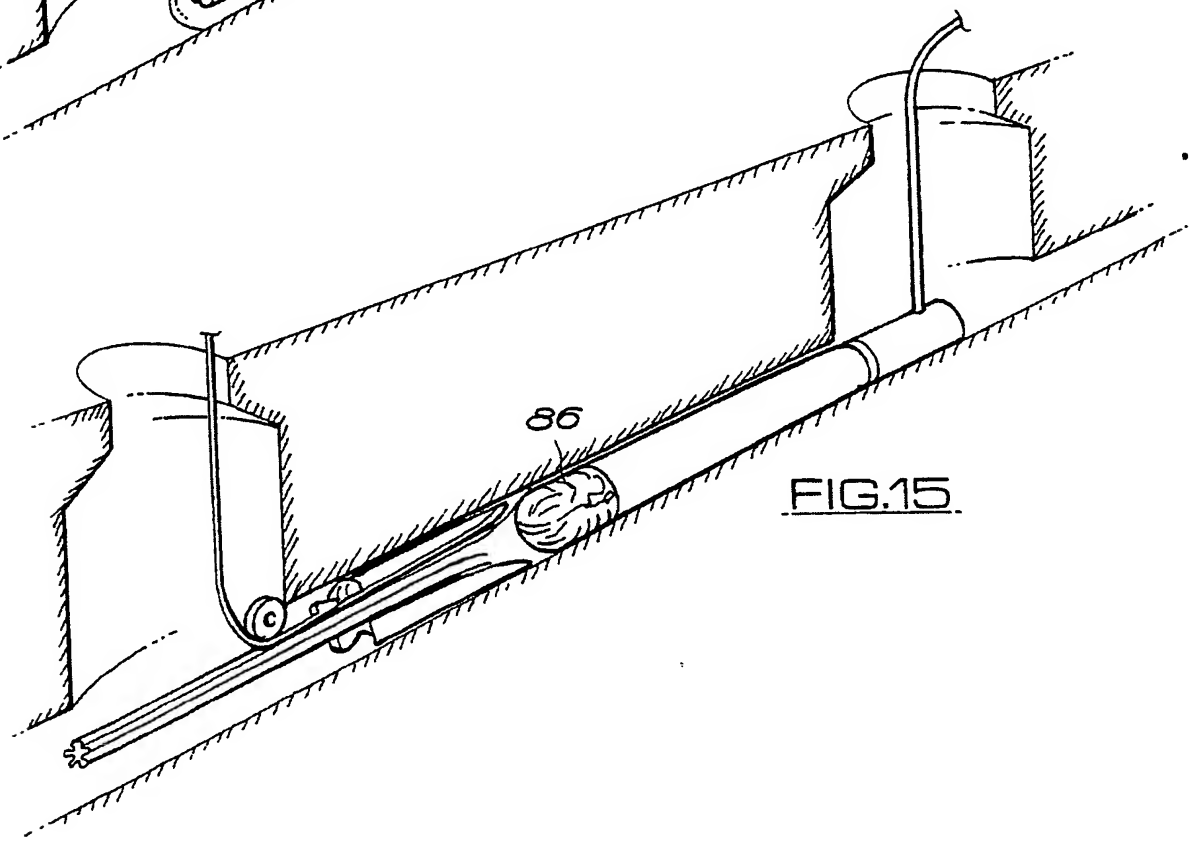


FIG.15.

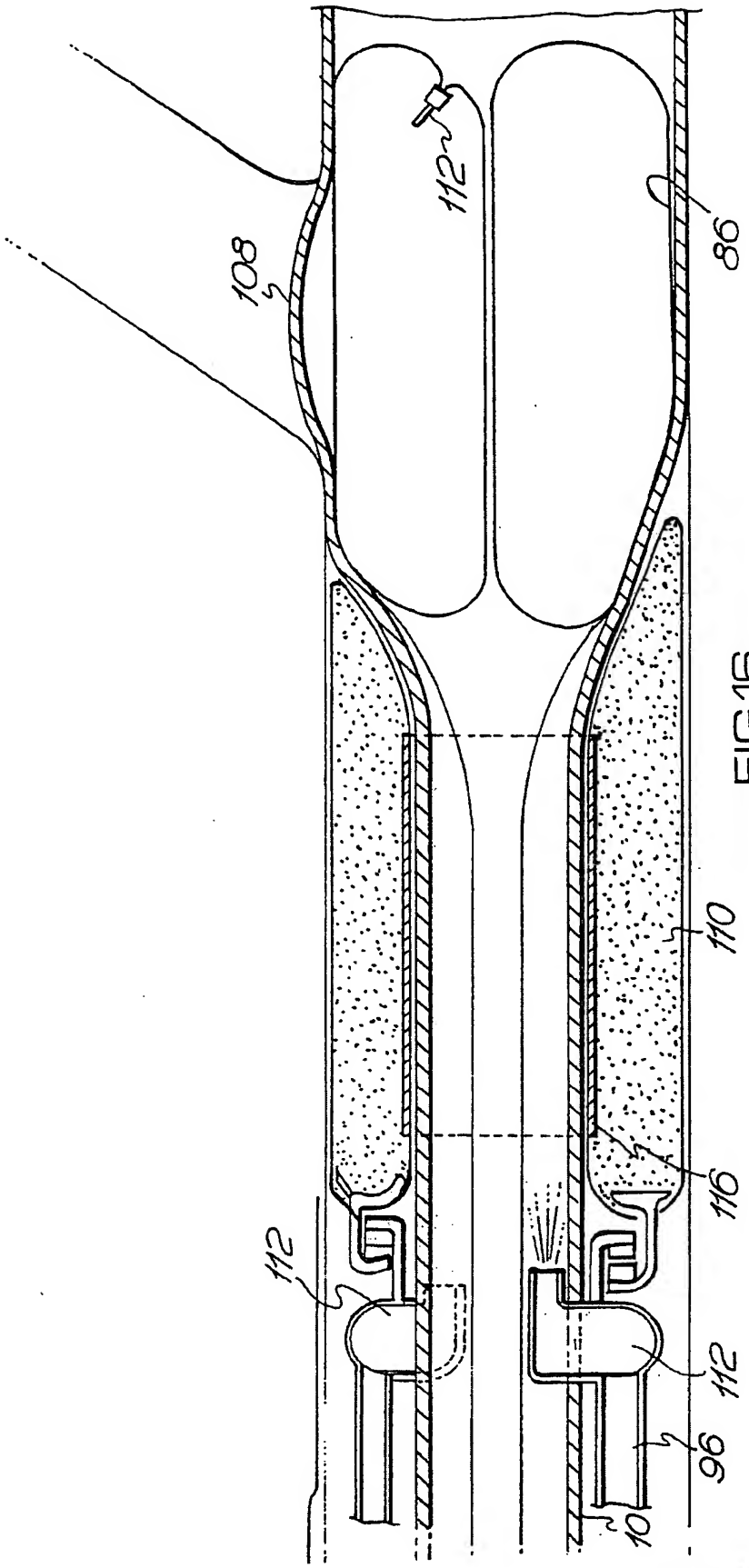


FIG.16.

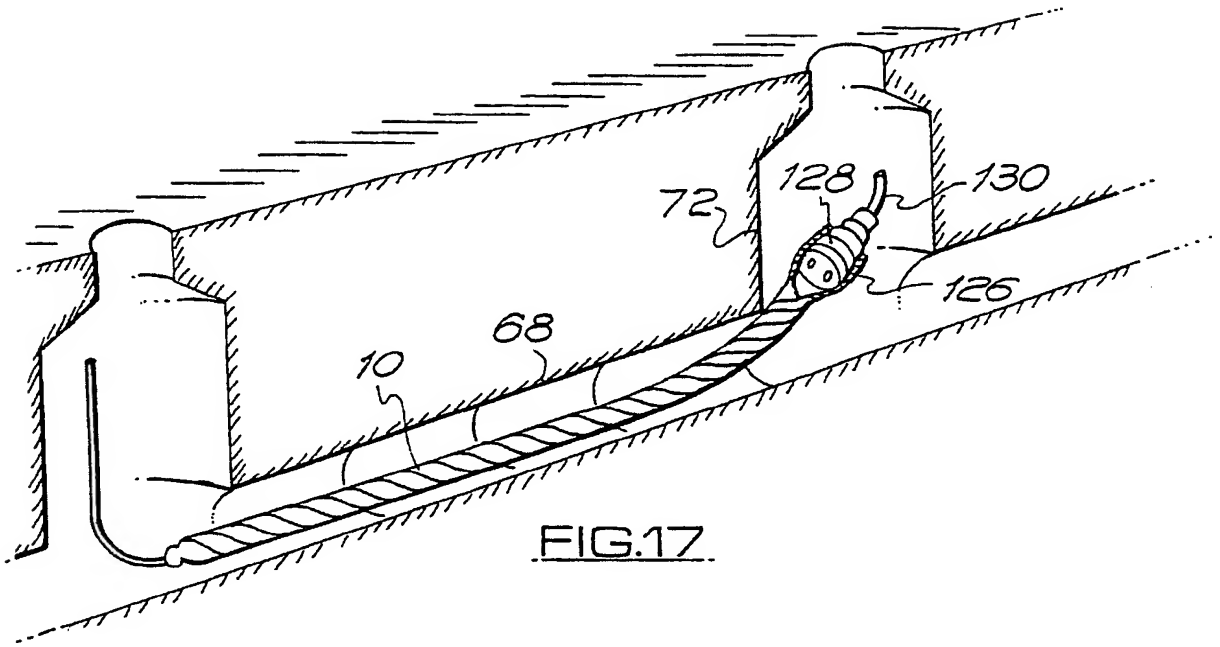


FIG.17

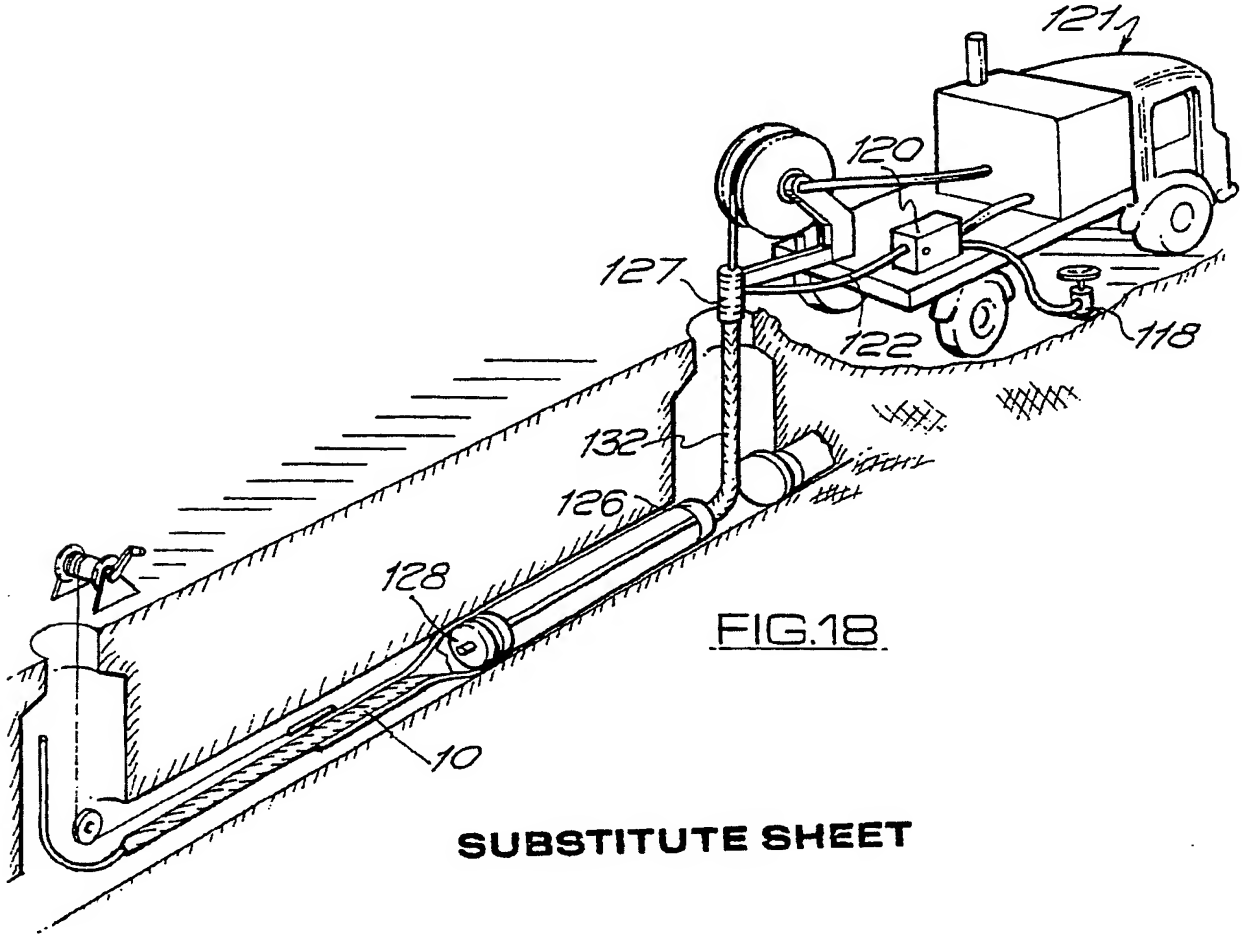


FIG.18

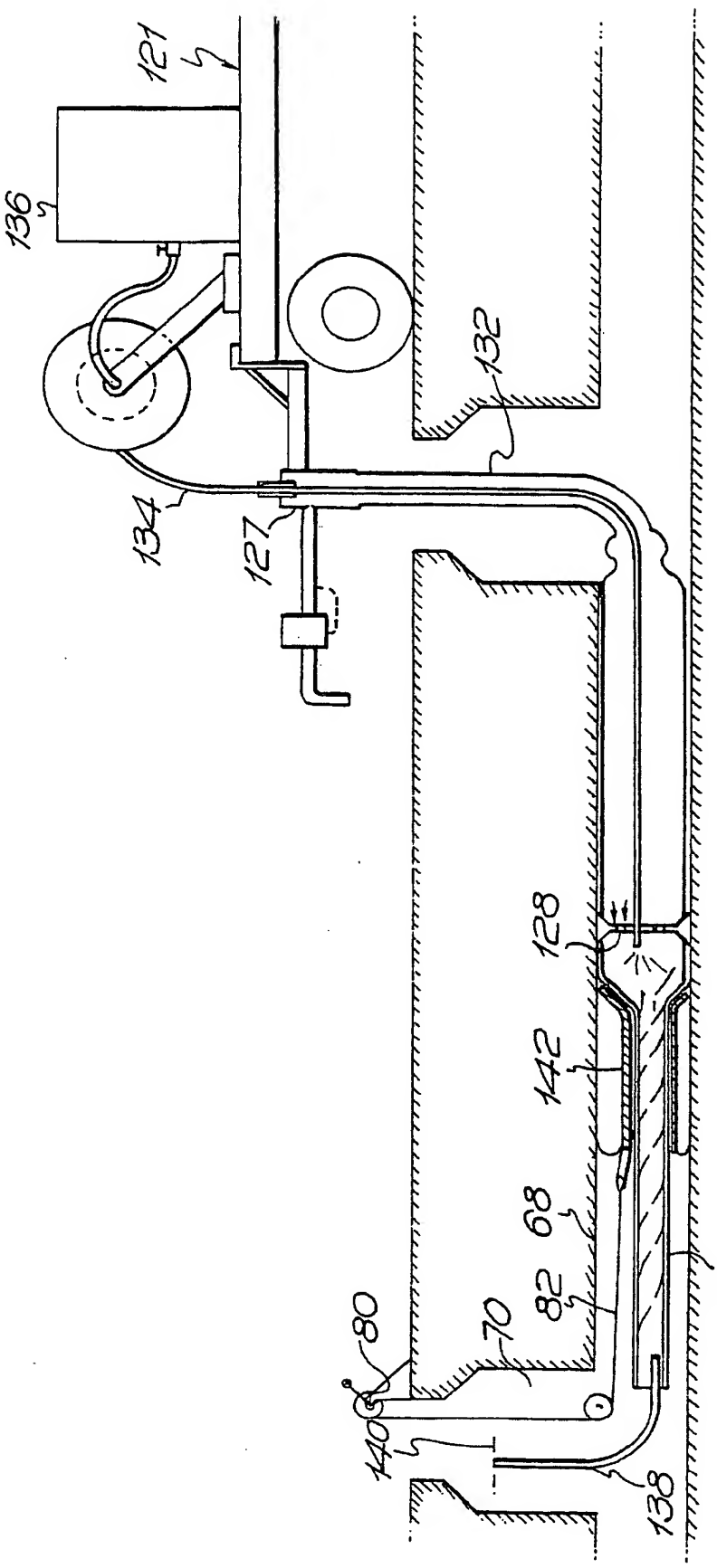


FIG.19

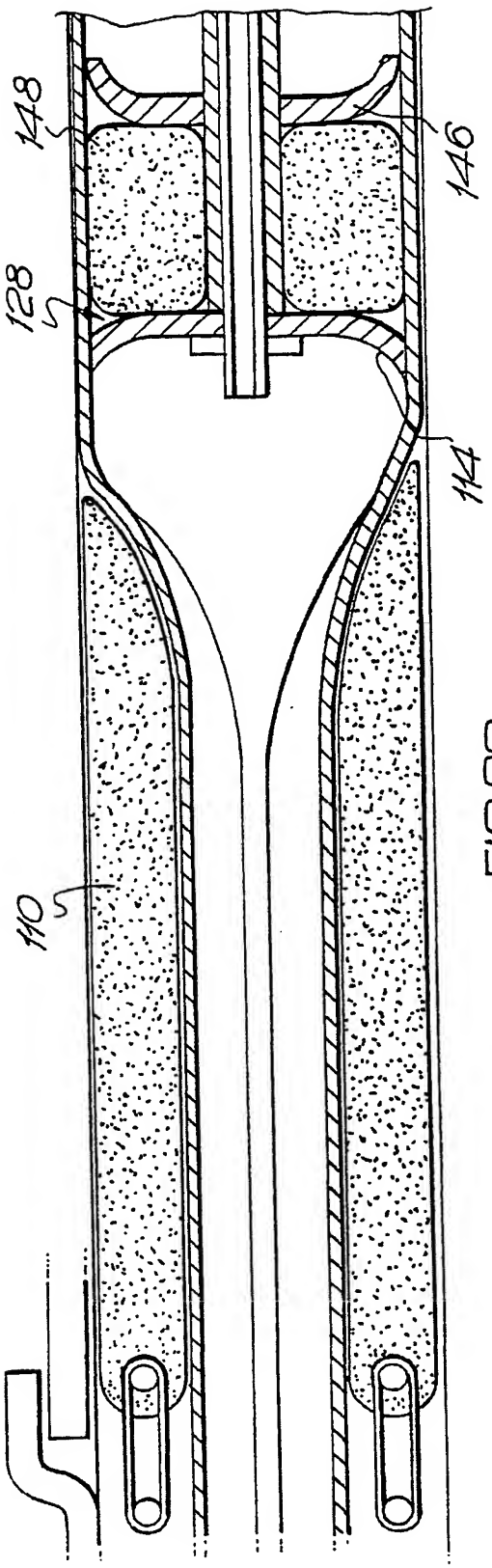


FIG.20

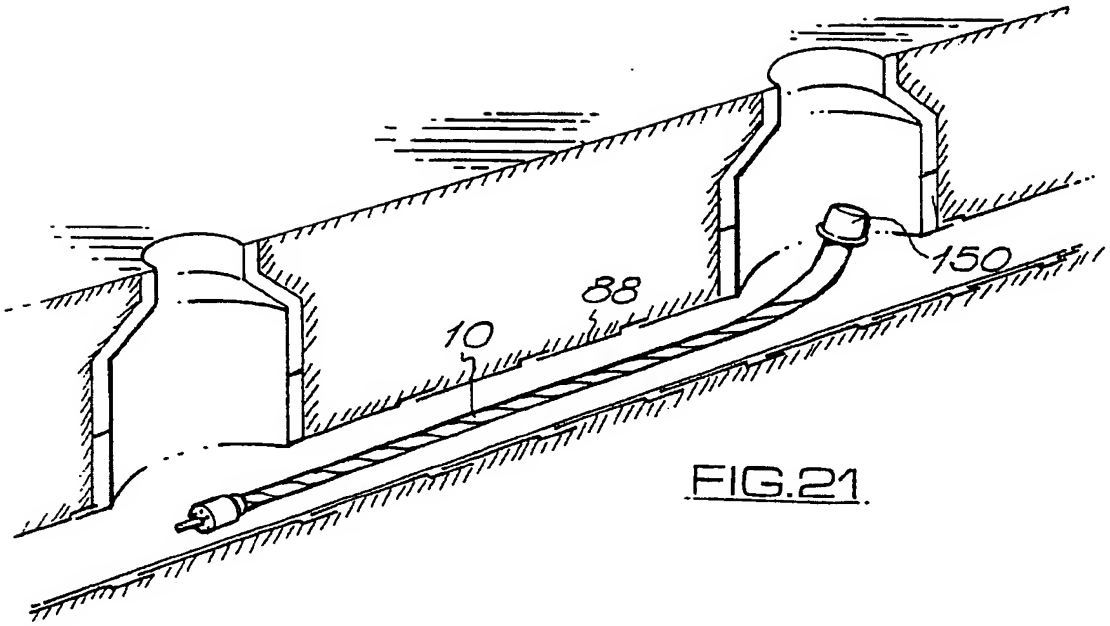


FIG.21

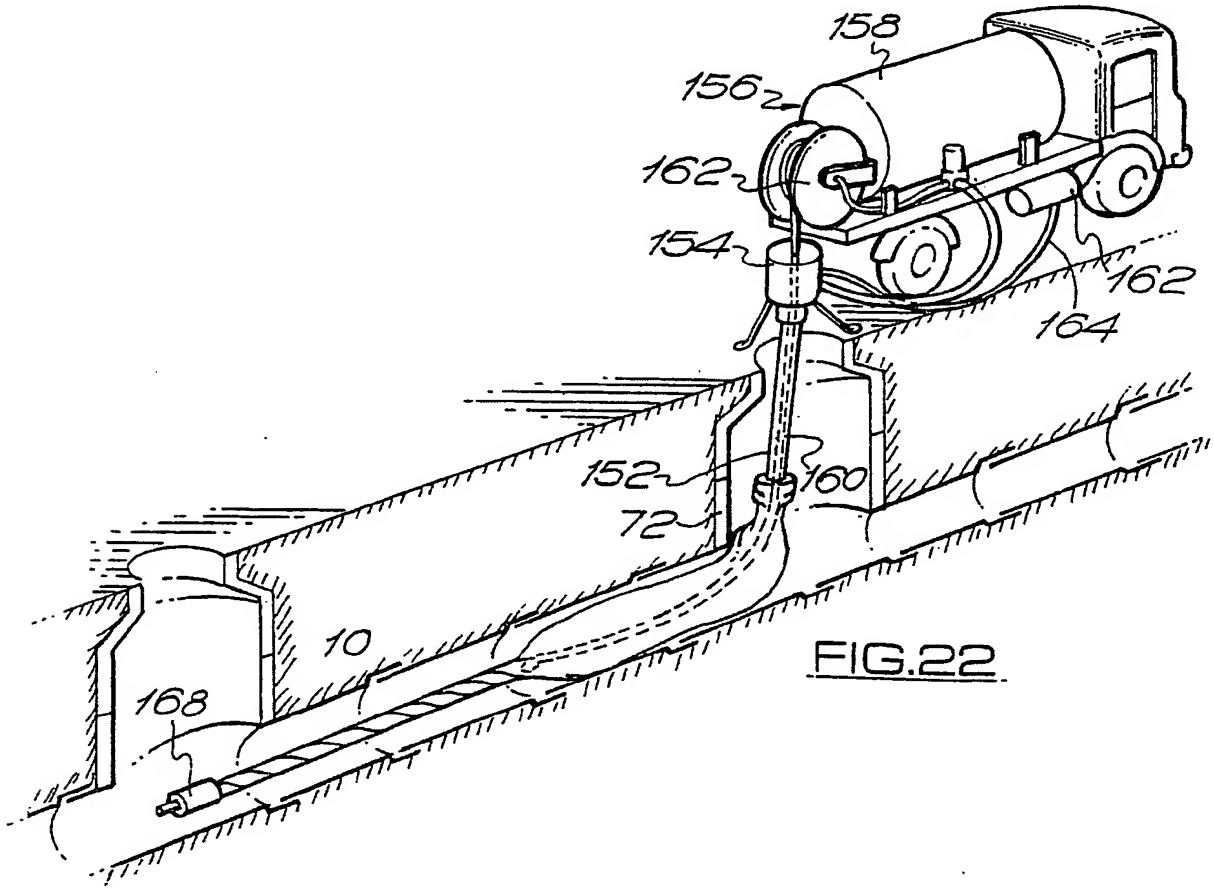


FIG.22

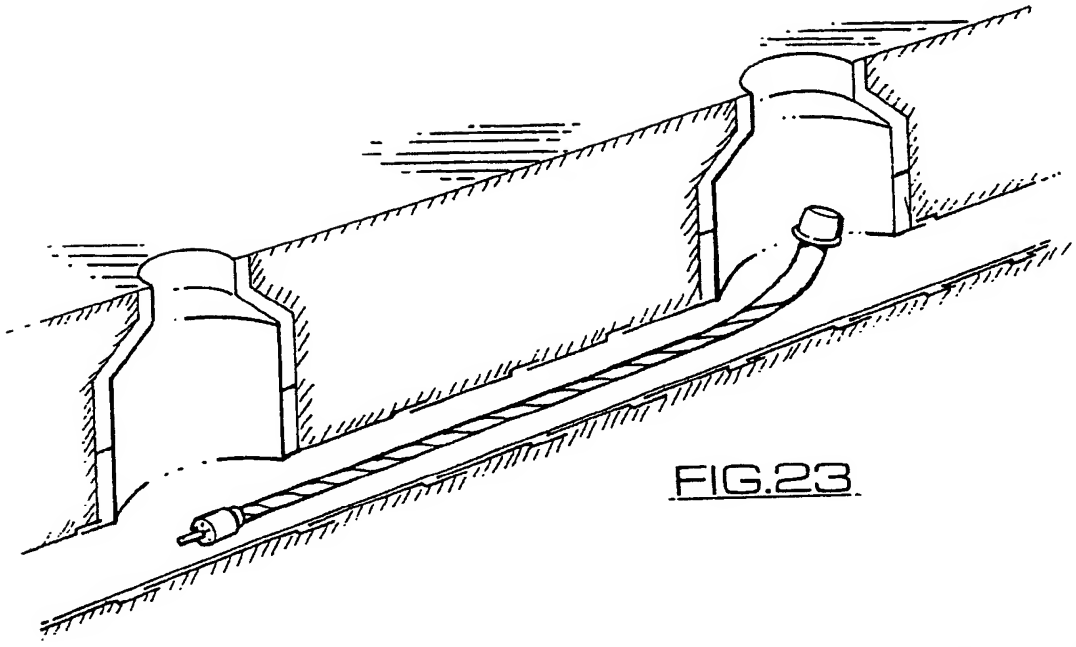


FIG.23

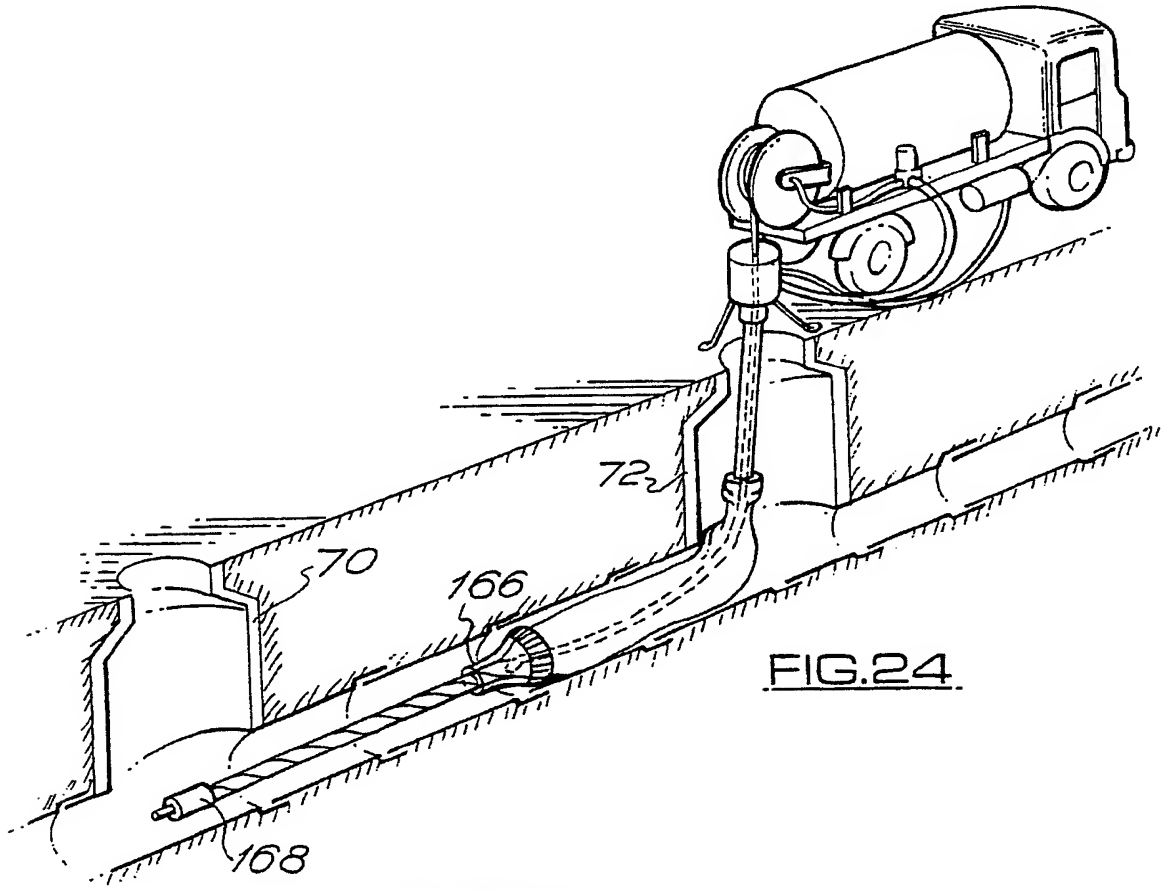


FIG.24

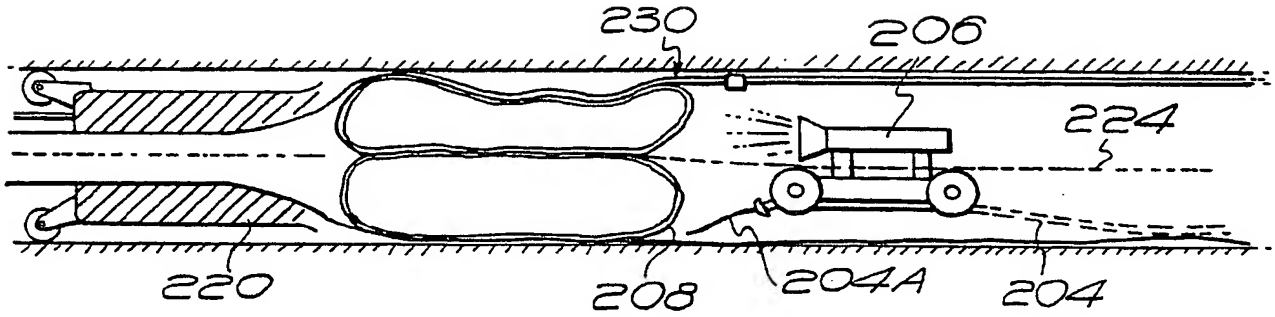


FIG.25

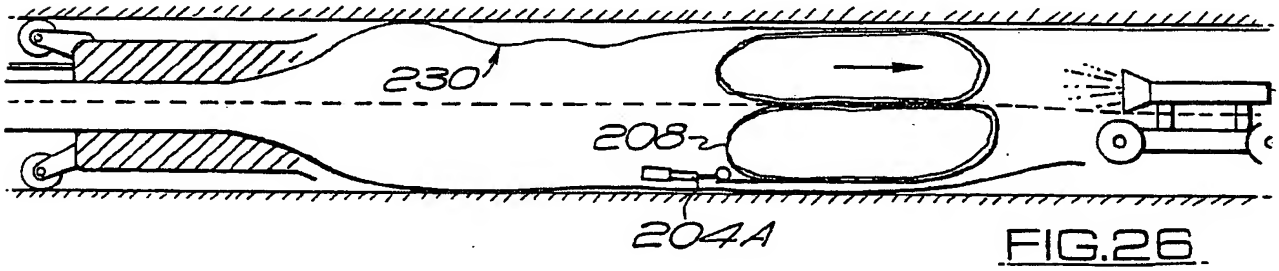


FIG.26

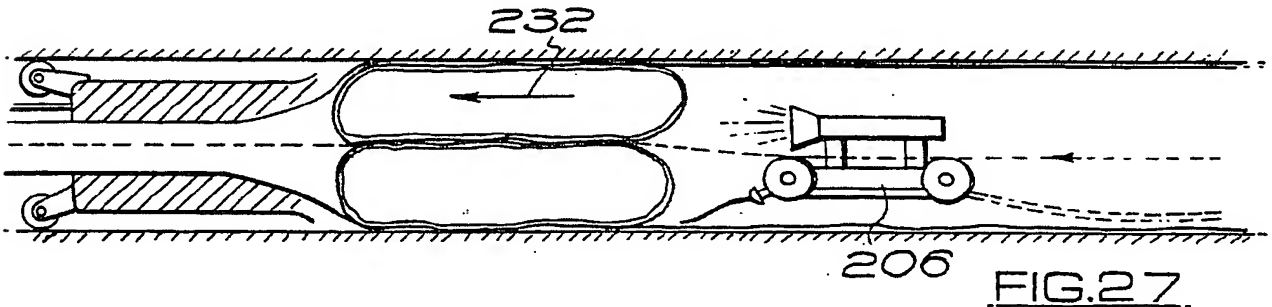


FIG.27

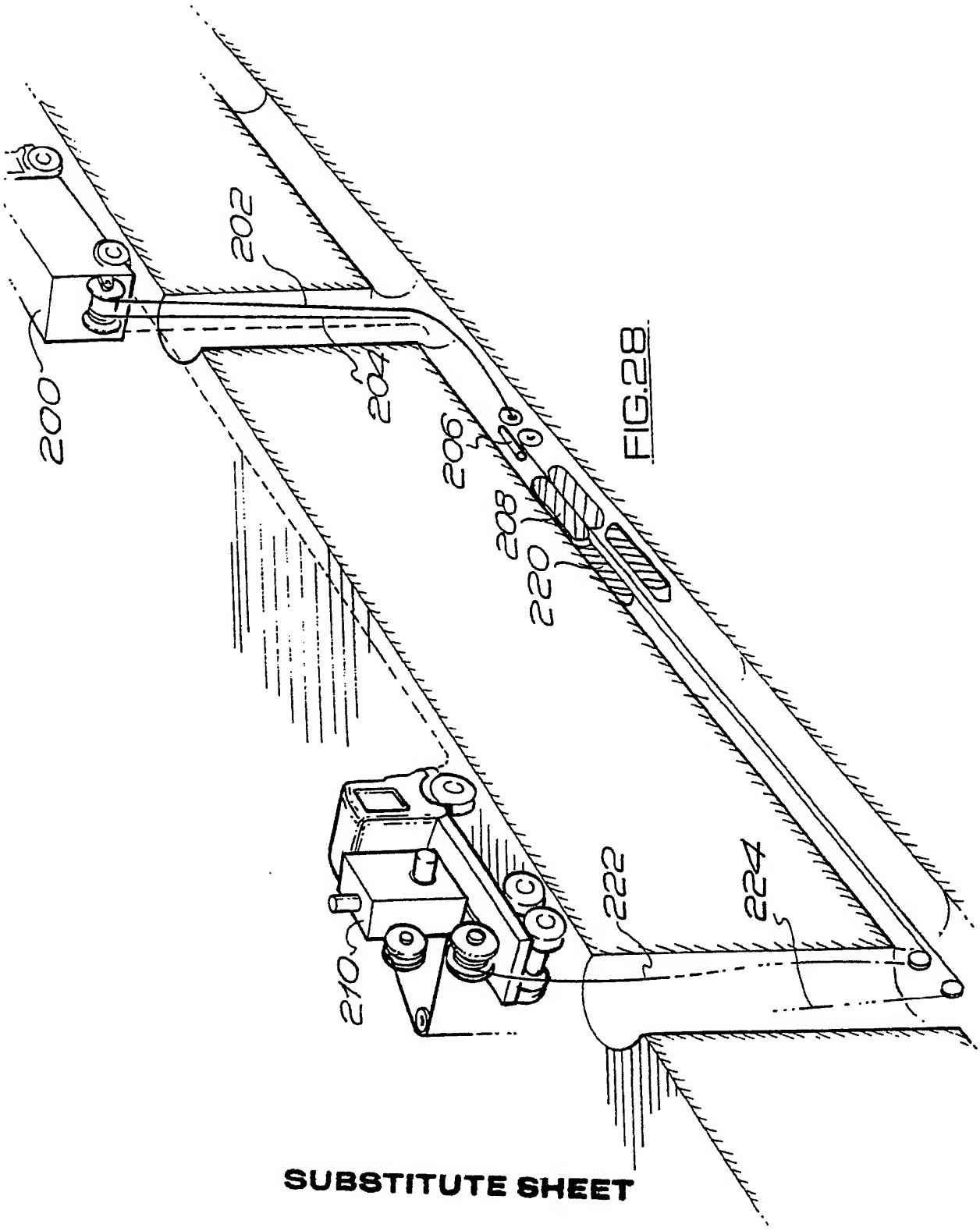


FIG.28

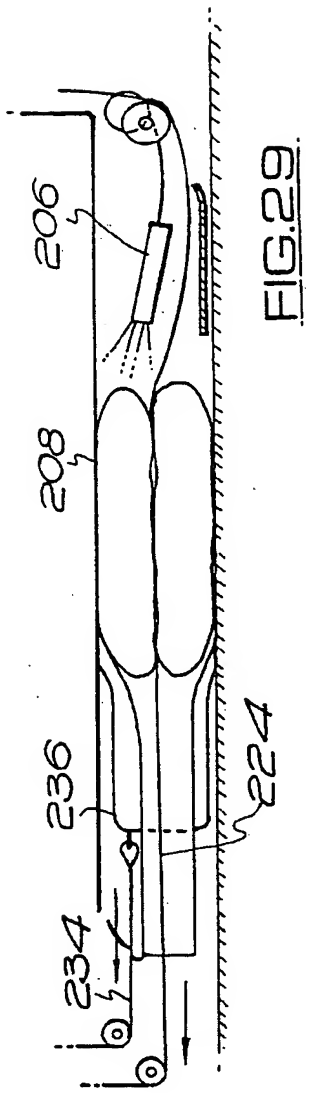


FIG.29

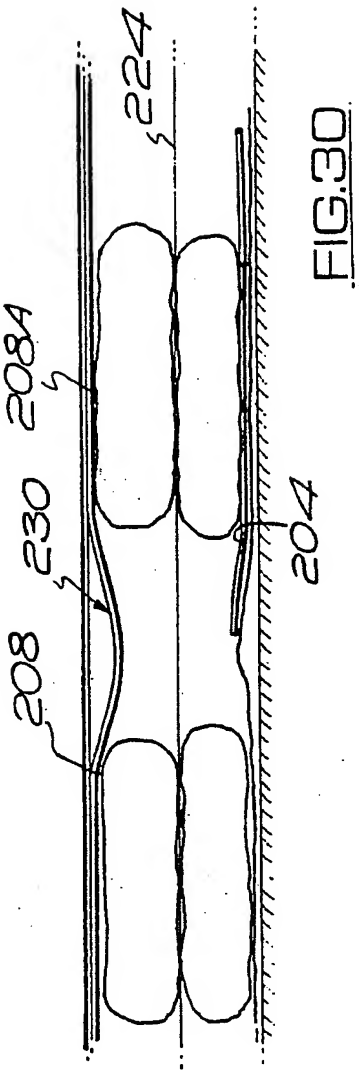


FIG.30

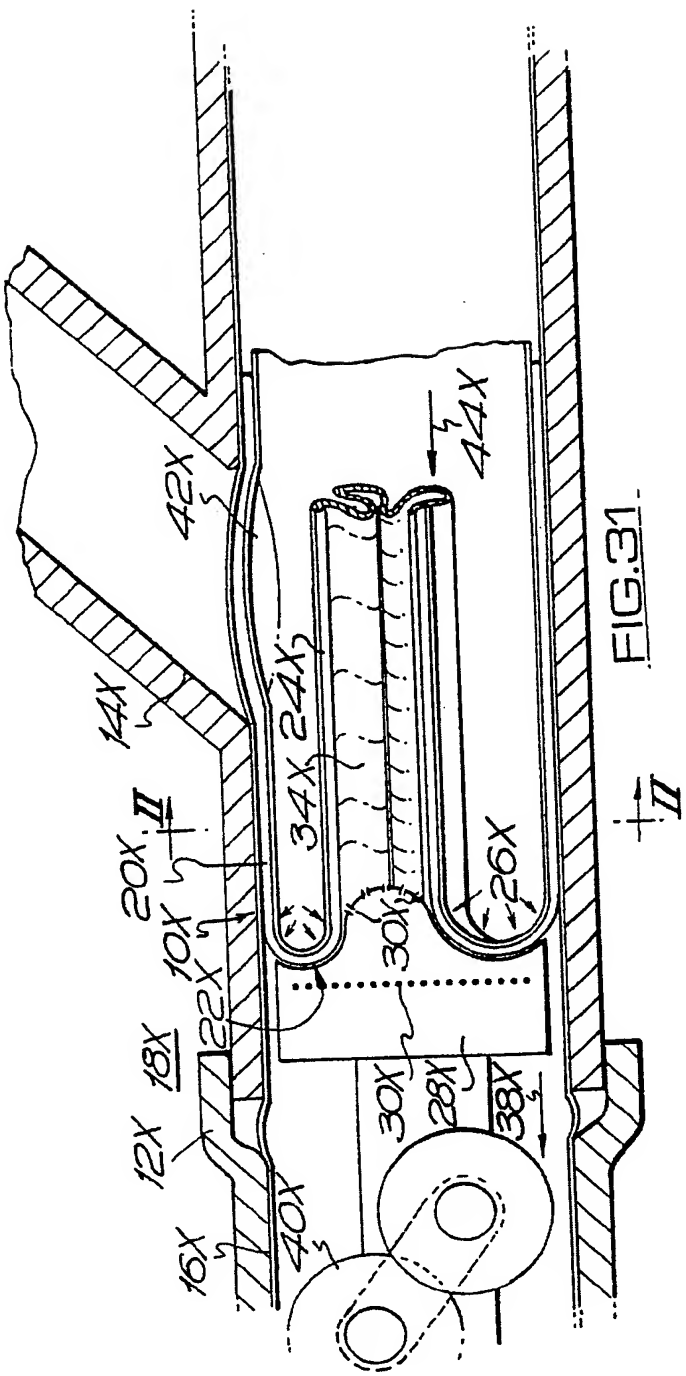


FIG.31

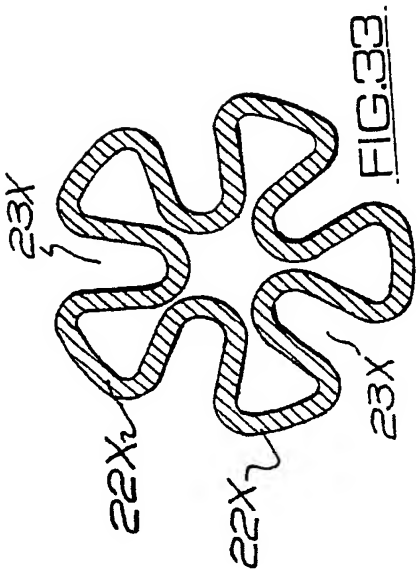


FIG.33

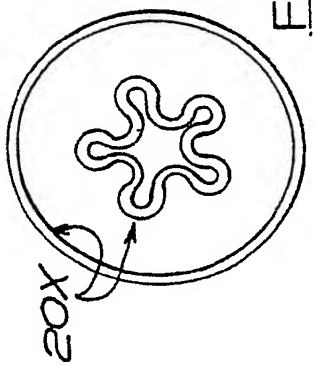


FIG.32

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 90/00512

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 F16L55/165

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	F16L

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
A	EP,A,65886 (J.LAURENT) 01 December 1982 see abstract; claim 5; figures	1-4
X	(cited in the application)	7, 12
A	GB,A,2208311 (CAMPBELL H STEKETEE JR.) 22 March 1989 see abstract; figures	1, 3, 4, 16
X		7, 9
A	EP,A,301895 (ANGUS FIRE ARMOUR LTD) 01 February 1989 see abstract; figures see column 3, lines 54 - 57	1, 2, 3
X		10, 11, 14
A	EP,A,298125 (OSAKA GAS CO., LTD) 11 January 1989 see abstract; figures	4, 6

° Special categories of cited documents :[10]

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"O" document referring to an oral disclosure, use, exhibition or other means

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
18 JULY 1990	21.08.90
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	BARTSCH A.W.

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

PCT/GB 90/00512
SA 35968

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 18/07/90
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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